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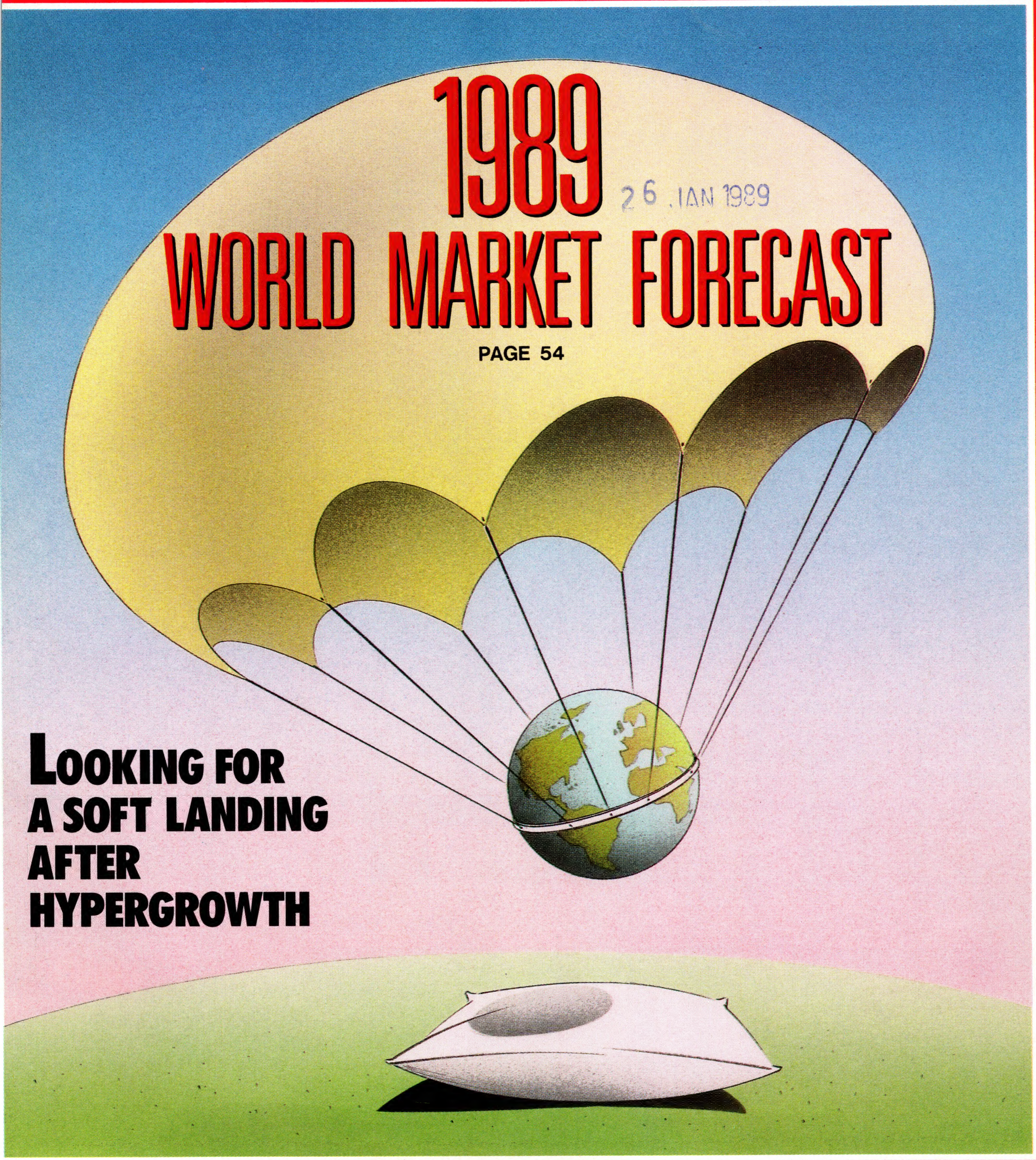

1989 WORLD MARKET FORECAST

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26 JAN 1989

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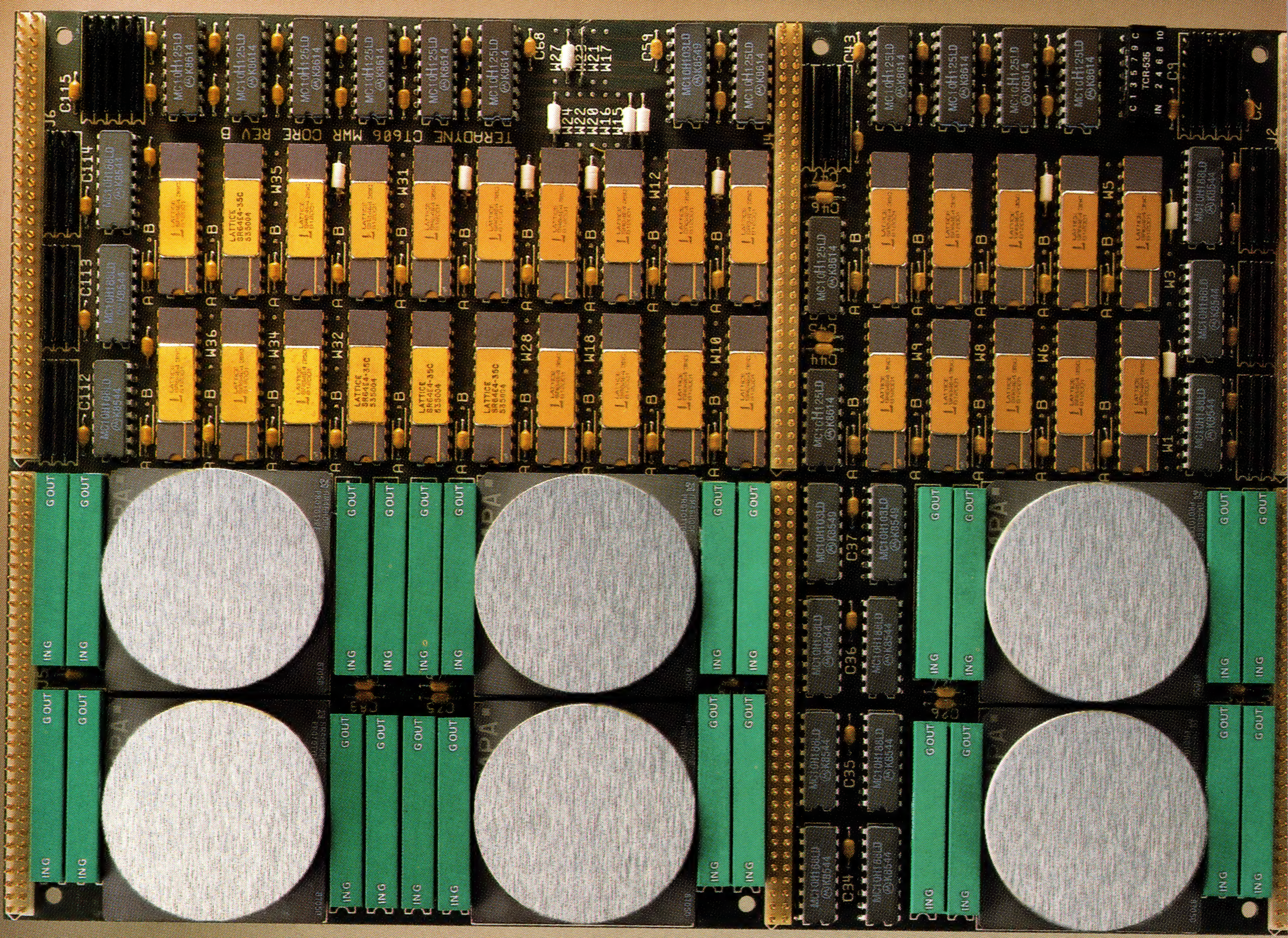

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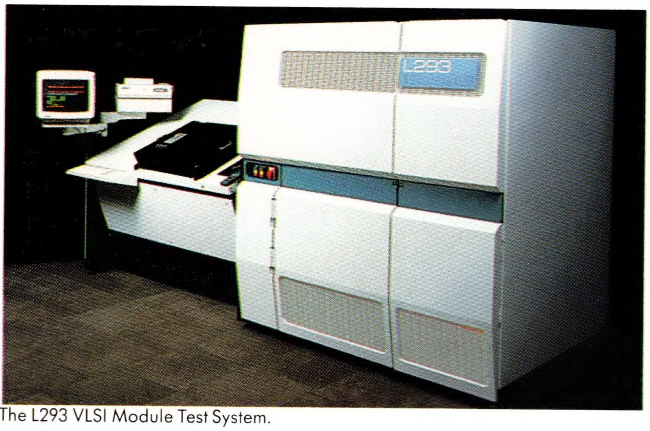

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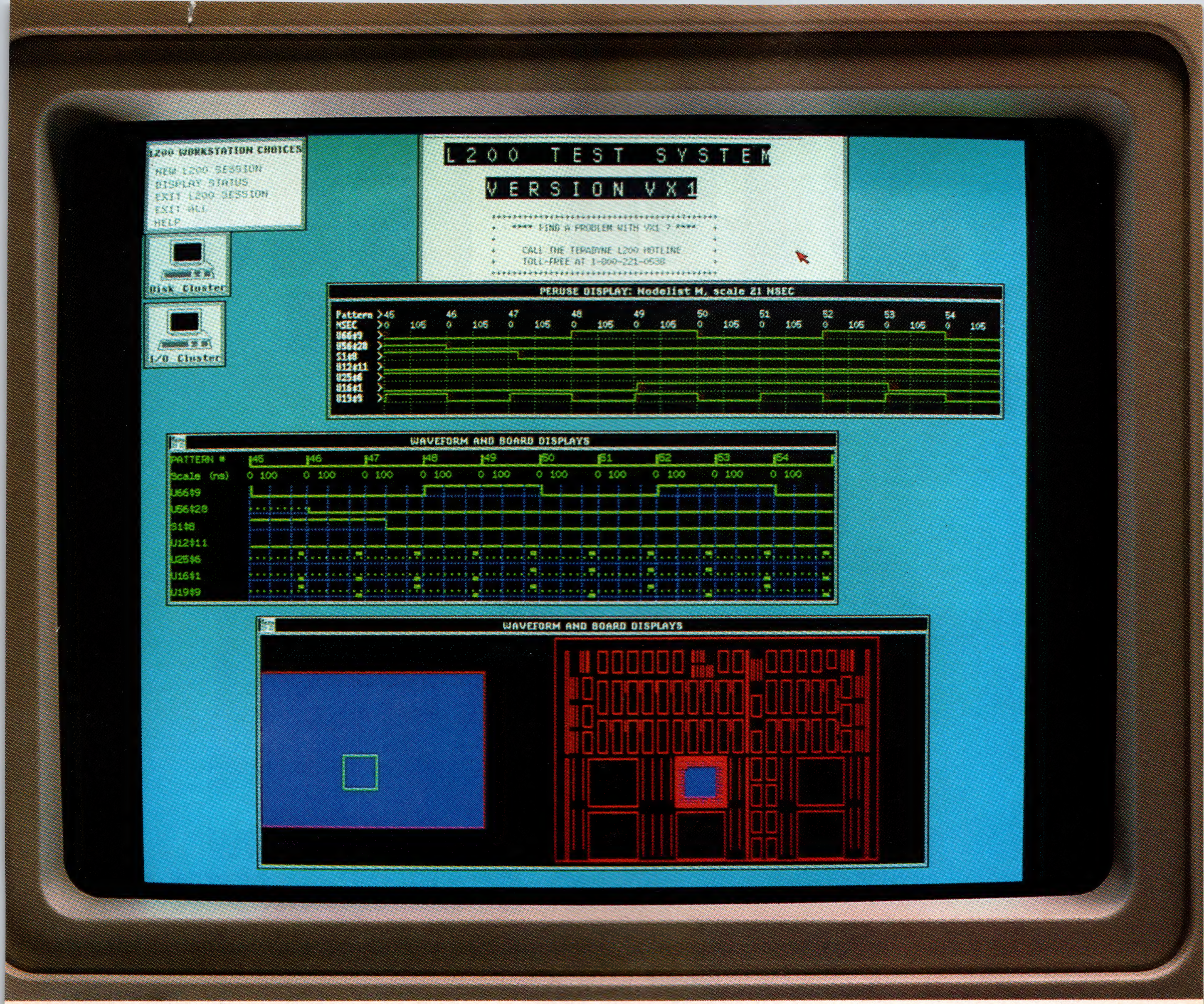

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Circle 1

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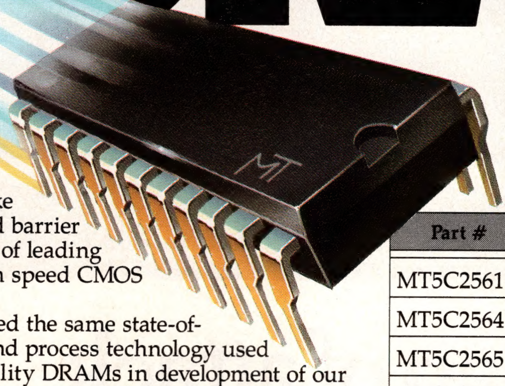

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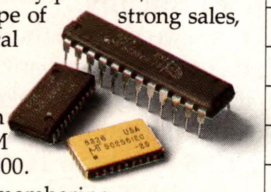

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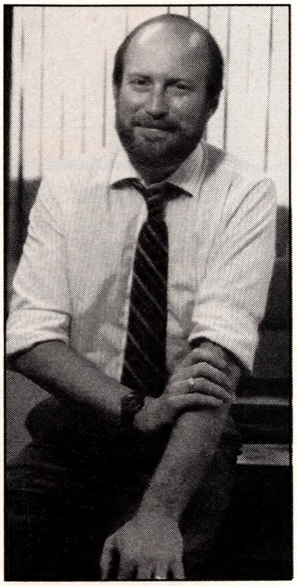
MEMORIES—THE LEGACY OF 1988

Some DRAM buyers are unlikely to forget being let down in the shortage; it's a lesson worth remembering



If 1988 was the industry's boom year that suffered one doozy of a memory lapse, then 1989 will certainly be remembered as a hangover year.

Opinions vary widely over whether that means that systems houses are more likely to still suffer from remnants of the dynamic random-amnesiac memories or if it will be the DRAM suppliers' turn. Either way, who'll forget the year that was in DRAMs? Not many, hopefully, because it underscores just how interconnected the years have been during the 1980s.

The Great DRAM Shortage, by most accounts, can be linked to overbuilt capacity in 1984 and the subsequent red-ink baths taken by the chip suppliers in 1985 and 1986: two years when capital spending on DRAM fabs nearly dried up. And then there was the systems viewpoint of 1985-86: memory was free. So software and operating systems exploded with huge storage needs, eventually compounding the sudden shortage and sending computer costs up instead of down.

Yes, there were big headlines about the still unresolved dispute between chip makers and systems houses over DRAM price-setting enforcement of the U.S.-Japan semiconductor pact. But there are some other unforgettable stories worth noting before 1989 grows old.

There's the one about a leading personal computer supplier debuting a zero-memory option in the darkest days of the DRAM shortage. It sounded crazy to me back in March when AST Research Inc. announced it, but today the Irvine, Calif., company still offers a 0-Kbyte option to add-on PC boards; resellers can plug in their own DRAMs.

And take the desperate case of SemiDisk Systems Inc., a maker of disk-emulation boards in Beaverton, Ore. Company president James Bell was angry (and still is) when his $2.70-a-piece 256-Kbit order was dumped by a distributor caught in the shortage squeeze. He protested with fliers handed out to DRAM customers attending the chip supplier's local seminar. "It was not something that I wanted to do, but I had to let people know this was unethical behavior," says Bell, whose company has survived and now prefers to deal in the gray markets over long-term supplier contracts. I wonder how many other entrepreneurs, startups, and small firms have permanently been turned off to vendor-customer pacts.

Unfortunately, that seems to be one of the legacies of what otherwise was a very good 1988.

J. ROBERT LINEBACK

January 1989 Volume 62, Number 1 110,371 copies of this issue printed

Electronics (ISSN 0883-4989). Published monthly by VNU Business Publications Inc. Publication office: Ten Holland Drive, Hasbrouck Heights, N. J. 07604; second class postage paid at Hackensack, N. J. 07602 and additional mailing offices.

Executive, editorial, circulation, and advertising addresses: Electronics, Ten Holland Drive, Hasbrouck Heights, N. J. 07604. Telephone (201) 393-6000. Facsimile (201) 393-6388. TWX 710-990-5071 (HAYDENPUB HBHT). Cable Haydenpubs.

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For subscriber change of address and subscription inquiries, call 215-630-4277.

POSTMASTER: Please send change of address to ELECTRONICS, P.O. Box 1092, Southeastern, Pa. 19398.

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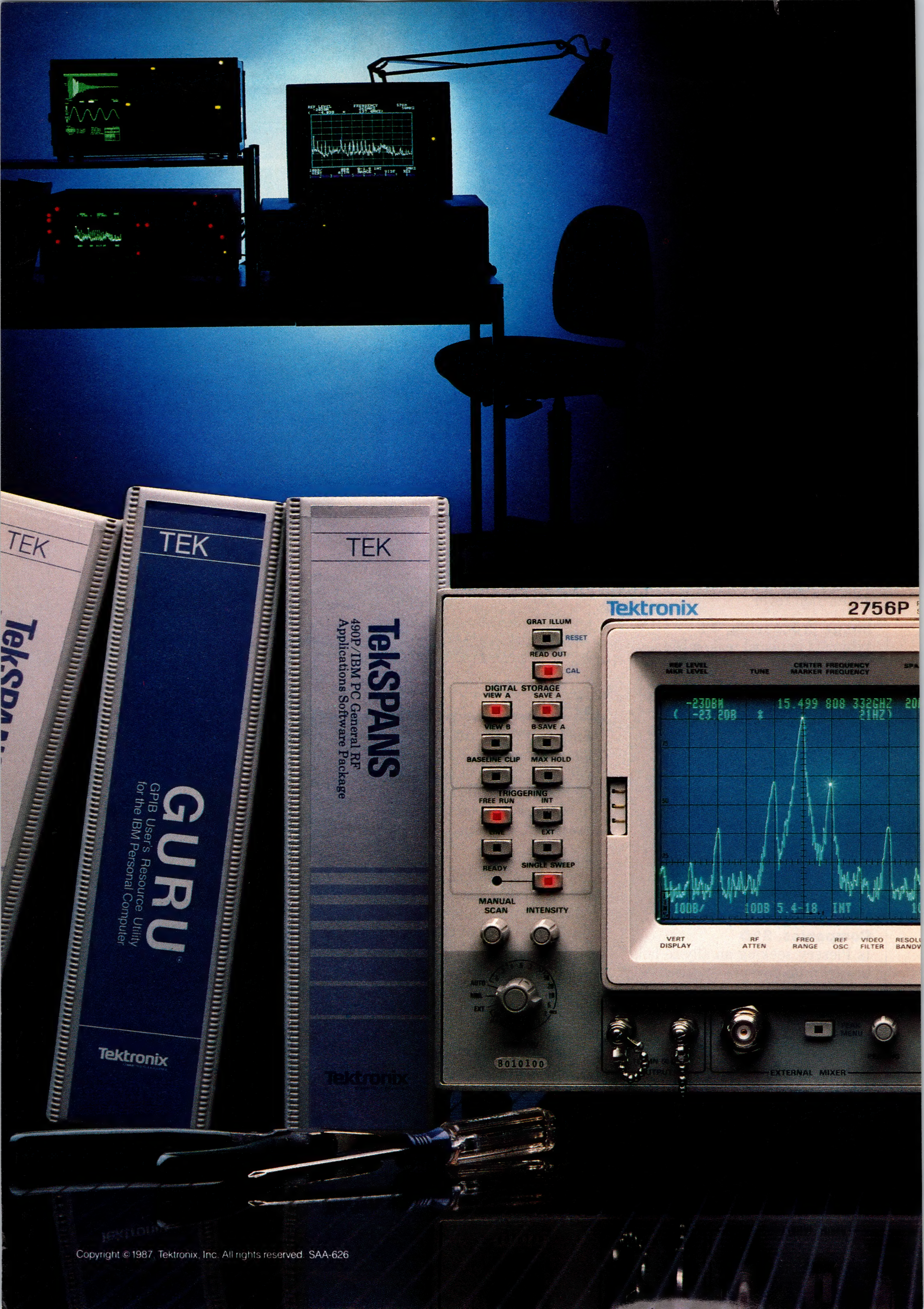

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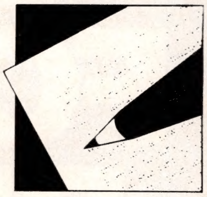
LETTER FROM ATLANTA

ELECTRONICS STARTUPS GROW LIKE PEACHES IN GEORGIA



ATLANTA, GA.

Much more than peaches is being harvested in Georgia nowadays. Soil that just 30 years ago would have been tilled is now being excavated by a thousand snorting bulldozers at an ever-faster rate. In the place of cotton, peaches—and even peanuts—electronics and other high-tech firms are springing up on the low-slung Georgia landscape north and east of one of the South's most cosmopolitan cities.

Atlanta's emergence as a technology center has been the result of careful planning and a skillfully crafted public-private-university partnership. During the late 1970s, Gov. George Busby cajoled the state legislature into paying for a study of the Silicon Valley's electronics industry and Boston's Route 128 corridor. The result, says Chuck Graham, president of the Audichron Co., was a mandate for the Atlanta business and academic community to "Go thou and do likewise." And along the way, the movers and shakers have faced a lack of infrastructure, a shortage of local venture capital, and a trade-show defection.

Georgia Tech University, says Graham, is playing a major role in Atlanta's metamorphosis into a high-tech enclave by supplying graduates from the largest school of electrical engineering in the country. Funding is also more than adequate: "Tech gets the most money for electronics research and development of any university in the U. S.," he says.

Georgia Tech's key contribution was in providing a home fo and nurturing the state's Advanced Technology Development Institute. Organized i 1983, it quickly established itself as one of the nation's mos successful business-incubato programs. Of the 100 companies that go their start through ATDI, 70 have staye the precarious course to financial viability. They employ 1,100 people and tall combined annual revenues of $110 million. The institute also conducts programs to advise potential entrepreneurs including an annual High Technolog Venture Capital Conference, and conferences designed for specific industrie such as biotechnology, computer graphics, and telecommunications.

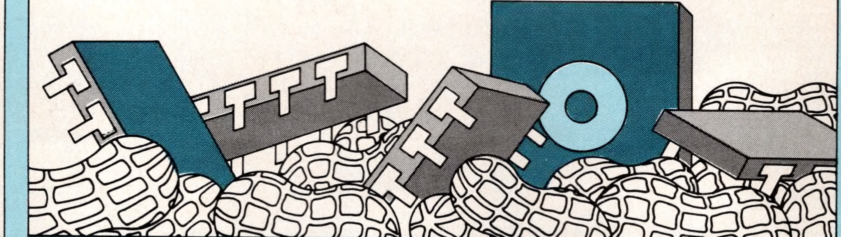
One reason for Atlanta's high-tech development is the movement of the South's textile industries offshore to Europe and Asia beginning in the 1950s "Women who used to be sewing dresses are now stuffing boards," says Ezra Mintz, president of Colorgraphic Communications Corp. "When the garment industry went abroad, the South didn' have anything to replace it and started marketing itself. Atlanta succeeded because it was already a crossroad city."

Although the success rate is high, the number of electronics firms operating in greater Atlanta does not begin to compare with the number in greater Boston and in the Silicon Valley. Its infrastructure, while growing, is still not mature

HIGH-TECH COMPANIES SPROUT IN GEORGIA

	Number of companies	Number of employees
1982	305	61,500
1984	560	98,000
1986	704	118,000
1988	816	126,500

SOURCE: ADVANCED TECHNOLOGY DEVELOPMENT CENTER



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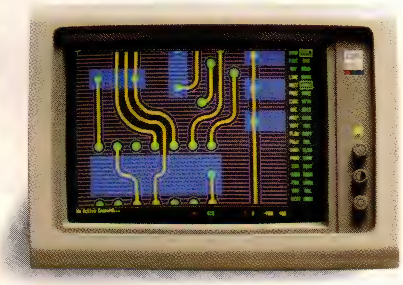

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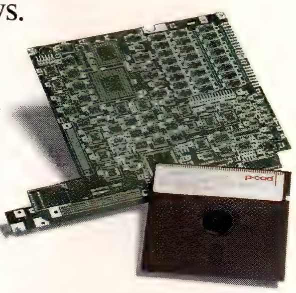

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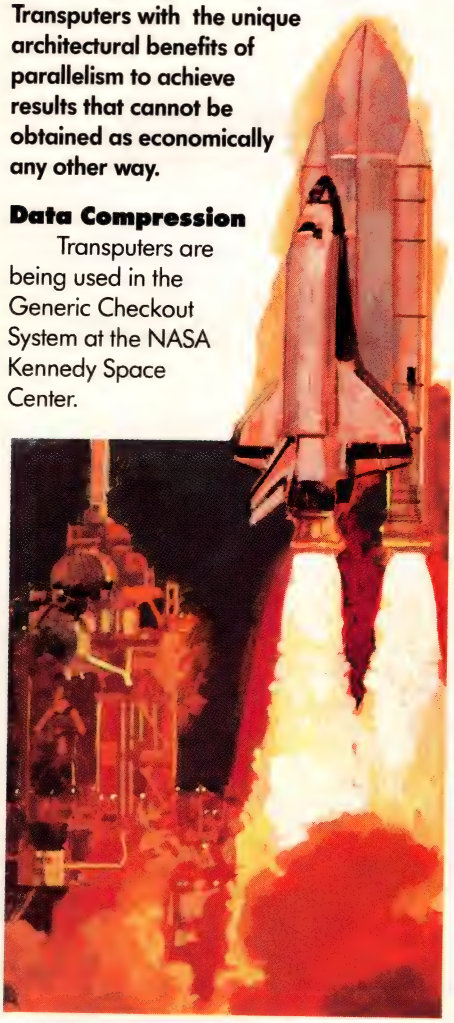
Data Compression

Transputers are being used in the Generic Checkout System at the NASA Kennedy Space Center.



They are embedded within VME based front-end Data Acquisition Modules to provide data filtering for the system.

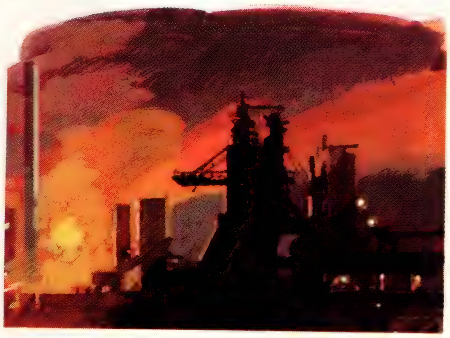
These modules pre-process data for a network of Unix based workstations that provide real-time control and monitoring of ground and flight equipment, like that used by the Space Shuttle. Only Transputers offered the degree of parallelism needed for this application.

Medical Imaging

University College London is using the parallel processing power of Transputers to convert CAT, NMR and laser scans into rotating 3-D images. These facial, skeletal, and soft-tissue images provide accurate computerized measurements to assist doctors with each step of an operation, and are also used by plastic surgeons to 'rehearse' operations for reconstruction.

Data Collection

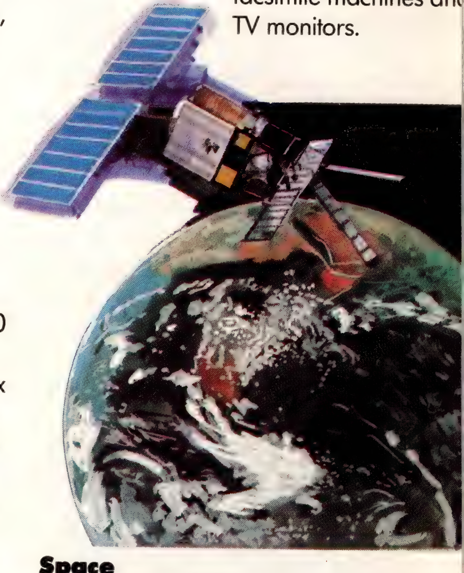
British Steel is implementing an intelligent system that is designed to dramatically cut its multimillion dollar annual energy costs. It is built around T800 floating point microprocessors which process information from a highly complex data gathering system. These Transputers operate in parallel, condensing enormous amounts of data into information which helps energy management decide how to respond to a plant's changing demands for different fuels.



Data Transmission

Kokusai Denshin Denwa (KDD), the Japanese international telecommunications company, has developed an image-processing video telephone using Transputers to manipulate and condense images for transmission over telephone links.

This image communications system uses 32 Transputers operating in parallel for ultrafast image processing. It can be connected to PC's to transmit images ove telephone lines, function as a video phon or be programmed to match the specifica tions of other receiving equipment, such facsimile machines an TV monitors.



Space

The European Space Agency is using Transputers to build a light-weight, radiation-tolerant, on-board computer for spacecraft. Programs which utilize Transputers in scientific computing and spacecraft control applications are also being developed in the U.S.

Transputers are manufactured on epitaxial silicon and have been shown to withstand aggressive tactical radiation levels.

PUTER'S TERRIFIC, AL APPLICATIONS?”

ght Simulation

British Aerospace have used nsputers to develop a low-cost ht simulator comprising a flat rld, ground- d, buildings, es and mountains – h an optional Head- display. Future enhancements l include the addition of undulating rain and a single or triple window play option.

American companies are also using nsputers to build high-performance ht simulators more cheaply. One U.S. nufacturer utilizes over one thousand 00 processors per system.

D Rendering

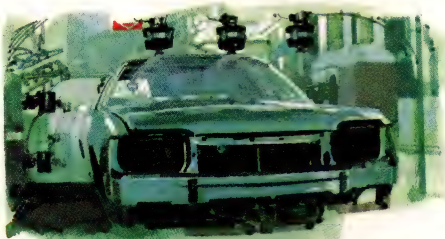
Pixar in the US has developed a nsputer-based rendering system which ickly renders photorealistic images from D models. The system consists of nsputer boards for VME and AT-bus stems optimized to run Pixar's phisticated rendering software.

The system holds great promise for such pplications as architecture, automobile tyling, package design, simulation as well s animation. Pixar's recent computer enerated film 'Tin Toy' could not have een done without using this ransputer-based accelerator.

System Control

As the number of Transputers in a system design are increased, a proportional increase in performance can be achieved.

In West Germany, Parsytec GmbH is using this principle in their Megaframe Superclusters. Superclusters represent a complete series of reconfigurable industrial control boards as used in the automotive industry, which exploit the Transputer's parallel processing capability.



The basic Model 64, built with T800's, has a performance of 640 MIPS and 96 MFLOPS. The Model 256 comprises four Model 64 cabinets connected by cables and provides 2,560 MIPS and 384 MFLOPS.

Parsytec believes there is no limit to the size Superclusters can grow to. Two Model 256s can be combined easily to realize twice the raw performance of one system.

Robotics

Transputers are ideally suited for robotics applications because their special on-chip links make communication between control centers naturally easy. They are often used in the central control area for dumb robots, in multi-jointed robots, and in machine vision systems.

At the Houston Space Center, NASA and Lockheed are using Transputers in the development of an intelligent, self-manoeuvering, voice-controlled robot named EVA Retriever. EVAR is being built to investigate the autonomous retrieval of objects and astronauts that become detached from the Space Station.

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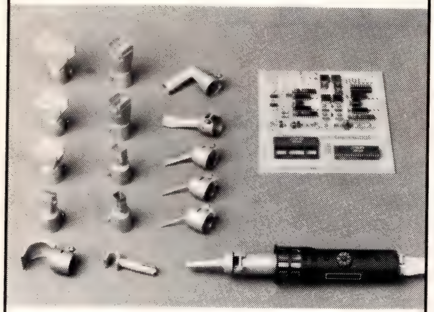

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ARUS6 001A-38
Electronics

enough to offer a supermarket of services to most electronics firms. "You still can't go out and have multiple subcontractors," says Bert Nordin, chief operating officer of Digital Communications Associates Inc. "There are a few printed-circuit-board companies here, but for volume work we go to Florida or Maryland."

On the other hand, the high-tech activity in Atlanta is vital enough to induce venture capitalists to hang their shingles here. Not too long ago, that was not the case. "Eight years ago, there was no home-grown venture capital here, but now it's an area no venture capitalist wants to overlook," says Bill McLendon, a partner in the Big Eight accounting firm Arthur Anderson & Co. McLendon estimates that $150 million to $200 million is available from venture capitalists in "funds grown locally by people who have their headquarters here." A much larger pool can be tapped through the branch offices that the major venture capital firms maintain in Atlanta.

Now, the missing element—seed money—has become available

Until recently, the major missing ingredient in Atlanta's financial stew has been significant seed money for the high-risk startups. "The venture capitalists are primarily interested in second-round financing," McLendon says, "and we didn't have a government-funded seed-capital operation." That all changed last year when the voters approved a $10 million proposal known as the Georgia Seed Capital Fund—still another program nurtured by the ATDI. This private-public partnership pledges $2.5 million from the state once the private investment community raises $7.5 million, says Don Plummer, ATDI's research and communications manager. The money will be parceled out in loans of between $50,000 and $500,000.

Still on the drawing board is a fund that will be used to guarantee loans to small high-tech companies that have gotten off the ground but have not been around long enough to meet the stringent requirements most commercial banks have for operating-capital loans. "That's down the road a bit," says Plummer, "but it is certainly something we are interested in and are pursuing."

Among the various areas of high technology, writing applications software for personal computers is one that has been on a sustained growth path in the Atlanta area since the mid 1970s, says Bill Goodhew, president of Peachtree Software Inc. in Norcross, Ga. Peachtree writes accounting software packages for small- to medium-sized companies. Privately owned, Peachtree employs 70 people and has an annual revenue of about $12 million. Larger software houses include American Software, HBO, Management Sciences America (better known as MSA), Stockholder Systems, and Samna. Diversity is the name of the game, and Atlanta's software industry resists being pigeonholed. "We don't have a specialty down here," says Goodhew.

But the Atlanta software companies don't cover every market area, either. Few companies are writing applications for Apple Computer Inc.'s Macintosh, and there's not much activity in systems software. "We don't have any computer hardware companies here, so there is no natural strategic partner, but I would call that a missing positive instead of a negative," says Goodhew.

Atlanta's physical infrastructure generally seems to be holding up quite well under the strain of development. However, at Hartsfield International Airport—which is one of the nation's main hubs, vying with O'Hare in Chicago for leadership in its average daily arrivals and departures—traffic is growing too fast for the airport facilities to handle. The city owns two sites that could be used to build another airport to take the pressure off, but its politicians are moving slowly. By the time Atlanta builds another airport, Hartsfield will be overloaded, observers say.

On the other hand, the telecommunications system in and around Atlanta is as up-to-date as any other in the nation. The local Bell operating company—Southern Bell—has pioneered the nation's first commercial multiuser network using the integrated services digital network standards and associated technology. It provides voice, data, and enhanced services on a network with users that include AT&T Network Systems, Contel, Hayes Microcomputer Products, Prime Computer, and SunTrust Services. A sixth customer, Digital Equipment Corp., was announced late last year. The new ISDN network in Dunwoody, Ga., is part of a $1.6 billion effort to computerize Southern Bell's central offices by the end of this year.

One of the biggest boosts to Atlanta's high-tech reputation came with the arrival a few years ago of the East Coast version of the Comdex trade show and exposition. However, that show is scheduled to move to Chicago this year. The apparent snub hasn't rattled Goodhew, who serves as president of the American Electronics Association's Southeast Council. "That was horse trading with the hotels here," he says. "When Comdex announced it was going to Chicago, PC Expo decided to do an Atlanta show and a lot of people signed up. So Comdex said it was just trying Chicago out, and the worst that we could have now is to have it alternate."

–Jack Shandle

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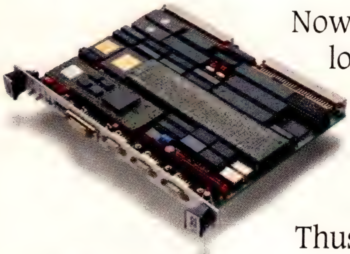

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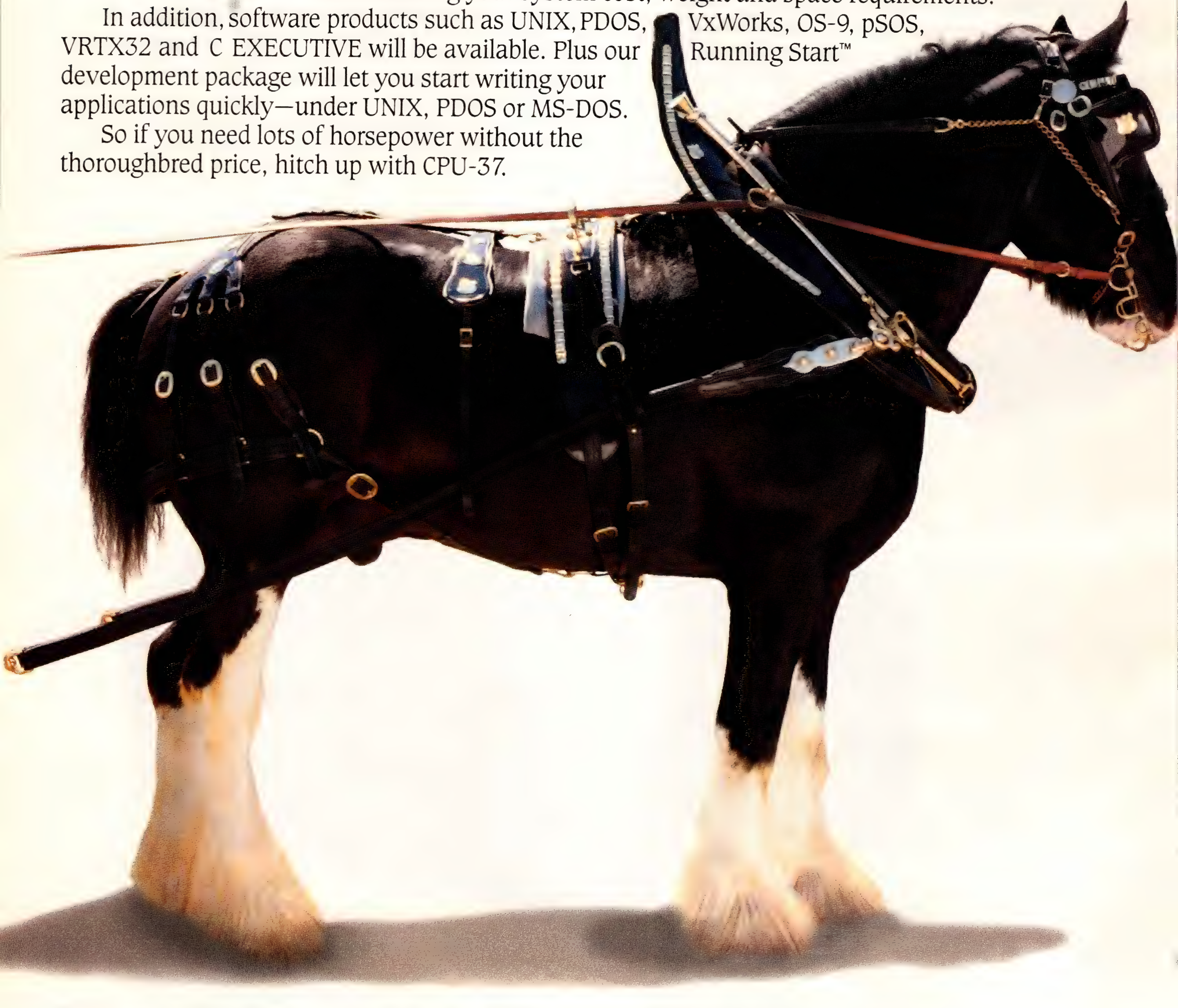

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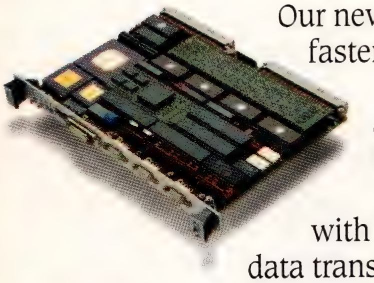

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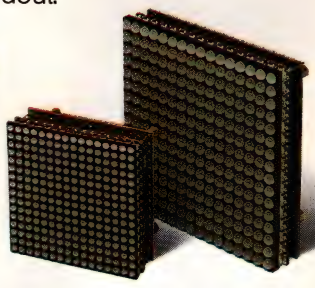
Circle 15

Toshiba LED Module Achieves Delicate Display with 16-Gradient Control.

The forms and functions of information and its handling are diversifying with great speed. Toshiba, a world leader in the opto-electronics field, has developed a 16 × 16 LED dot matrix module that opens new possibilities in information display. By combining these modules, a display equivalent to that of a TV can be realized. By use of Toshiba's outstanding two-color LED together with its unique gate array for driving, 16-gradient control is achieved in this new product. Compact design makes the module lightweight and optimally thin. Unique heat radiation design greatly improves the dispersion of heat from the module, and connections are simple, ensuring freedom from maintenance. In applications ranging from simple messages to visual displays such as message boards, entertainment and projector use, Toshiba's LED module is a standout.

CHARACTERISTICS	**DETAIL**					
Type Name	TLMM501B2	TLGM501B2	TLSM501B2	TLMM502A1	TLGM502A1	TLSM502A1
Color Display*	Red, Green, Amber	Green	Red	Red, Green, Amber	Green	Red
Dot Size	ø5mm			ø3mm		
Dot Pitch	6mm			4mm		
Weight (Typ.)	170g	165g	165g	95g	85g	85g

*Amber color is made by a mixture of red and green.



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Circle 16

JANUARY 1989

ELECTRONICS NEWSLETTER

HITACHI AND EDS REPORTED READY TO BUY NATIONAL ADVANCED SYSTEMS

Everyone says National Advanced Systems is on the block, but Hitachi Ltd. is doing something about it. The Japanese computer maker, in a partnership with General Motors subsidiary Electronic Data Systems of Dallas, will become the majority owner of National, the subsidiary of National Semiconductor Corp. of Santa Clara, Calif., that sells Hitachi's machines in the U. S. One immediate change: Hitachi, which will be the majority partner, will start selling mainframes in the U. S. under its own brand name. At the same time, Hitachi will purchase National Advanced Systems' European subsidiary with a different partner, BASF Corp., the chemical giant based in Ludwigshafen, West Germany, which now markets Hitachi mainframes. ☐

INTEL'S UP AND NATIONAL'S DOWN IN ANNUAL TOP 10 RANKING

The big news in the Integrated Circuit Engineering Corp. ranking of the top 10 semiconductor suppliers worldwide by annual sales is the changing fortunes of Intel Corp. and National Semiconductor Corp. Intel improved its standing by moving up to the sixth spot from No. 8 in 1987, while National fell out of the top 10 completely, dropping from the seventh to the eleventh spot, reports the market consulting firm in Scottsdale, Ariz. NEC, Toshiba, and Hitachi still hold the top three spots, says William McClean, the ICE vice president who compiles the ranking. Intel moved up on the strength of its booming microprocessor sales that sparked a fantastic overall growth rate of 57%. National's drop came despite its overall growth of 22%, which is perhaps two thirds of the industry's growth rate. The decline is largely because its lines are mainly in slower-moving bipolar and analog parts, says McClean. ☐

IS THE MICROPROCESSOR SET TO INVADE TELEPHONE CENTRAL-OFFICE SWITCHING?

GTE Laboratories Inc. in Waltham, Mass., is out to improve the versatility of telephone network switching by introducing microprocessor-based distributed control. GTE Labs is developing prototypes of systems based on link switches—which are autonomous, cooperating microprocessor-based controllers that relieve the central-office switch of much of the call-routing and customer-service management functions. This will allow network capacity to be expanded over an extremely broad range, simply by adding more microprocessors at the link switches. The firm says such distributed control, dispersed throughout the telephone net, is still a few years away. It also means that call-processing computers in the central-office switches need not be redundant to prevent a total system failure. If a link switch fails, calls will be routed to another. GTE won't say what microprocessors it's using. ☐

NOVEMBER'S BOOK-TO-BILL UPTURN BRIGHTENS THE OUTLOOK FOR 1989

Although only a slight uptick, the November book-to-bill ratio of 0.95 for semiconductors came as a welcome omen to the industry. The steady slide since May from the 1.4 level had made executives fearful that a debacle like 1984's might loom ahead. Moreover, the improvement was not really expected by most market forecasters. "It's very encouraging," says Jack Beedle, president of In-Stat Inc., a market-consulting firm in Scottsdale, Ariz. "It shows we're not falling off the cliff." The uptick has prompted Beedle to revise his forecast for 1989 to one of flat growth worldwide, rather than a fairly sharp dip. He does see the U. S. market as dropping about 3% from 1988, mostly from lower pricing. One financial analyst who foresaw the November uptick was Michael A. Gumport of New York's Drexel Burnham Lambert. He now projects orders turning up in the next six months, with U. S. growth between 5% and 10% for the year. ☐

ELECTRONICS NEWSLETTER

A NEW LASER TECHNOLOGY COULD LEAD TO OPTICAL COMMUNICATIONS IN COMPUTERS

Multiple high-power lasers integrated onto silicon chips could pave the way to wireless optical interconnections between high-density components. That's the promise the David Sarnoff Research Center sees in its new surface-emitting laser technology that for the first time allows many lasers to be combined coherently on the same chip for higher output. "We have gotten rid of wires in the telephone network—a large computer—and replaced them with fiber optics," says Michael Ettenberg, director of the Princeton, N. J. center's optoelectronics research laboratory. "Now, we are going to get rid of wires inside the conventional computer." He envisions laser-driven multiplexing of all I/O pins onto a single high-speed data channel. The Sarnoff research team replaced the feedback mirrors with gratings, added while the chip is being fabricated with an optical process. The gratings produce first-order effects that feed light back into the laser to boost power, plus second-order effects that leak some light perpendicular to the direction of existing light. The small amount of light leaking to an adjacent laser in a row of the devices fabricated side by side locks them in phase. Another benefit: with such an array, the Sarnoff researchers have produced 1 W of power—40 mW is now considered a high-power output for a diode laser. □

NOW THAT HONEYWELL HAS SNEEZED, WILL ETA CATCH COLD?

It's a nervous time for ETA Systems and a handful of other computer makers that buy integrated circuits from Honeywell Inc. The Minneapolis firm said late last year that it is putting its sprawling 268,000-ft^2 Colorado Springs, Colo., chip-manufacturing plant on the block. Honeywell says it intends to find a buyer that can support its own internal IC requirements during an unspecified transition period, as well as one who will continue to support Honeywell's outside chip customers, including ETA and Honeywell Bull. For ETA—Control Data Corp.'s supercomputer subsidiary in St. Paul, Minn.—a smooth transition to new ownership could be particularly important. At the heart of its ETA^{10} supercomputer are 20,000-gate array chips that Honeywell produces in its 1.25-µm CMOS process at Colorado Springs. ETA buys an estimated 3,000 to 5,000 arrays a month, and it has been slow to bring on its second-source chip supplier, Performance Semiconductor Corp. of Sunnyvale, Calif. [*Electronics*, Nov. 13, 1986, p. 22]. Any supply glitches could only complicate problems at Control Data, which has been experiencing losses since the third quarter of 1988. □

CONTROL DATA SHUFFLES ITS TOP MANAGEMENT

Meanwhile, Control Data Corp. unveiled a top-management shuffle last month, naming Lawrence Perlman as president and chief operating officer at the Minneapolis firm. Perlman, who has most recently headed up Control Data's Imprimis disk-drive operation, got the nod for the No. 2 job, reporting to chairman and chief executive officer Robert M. Price. John K. Buckner, previously executive vice president and chief financial officer, was promoted to vice chairman, and will remain as chief financial officer. Thomas C. Roberts, president at Control Data's troubled Systems and Services Group, will be leaving the company. "There were three guys who wanted that [No. 2] position, and there was a winner, a loser, and a consolation prize," says Gary Smaby, an analyst for the investment firm Needham & Co. Inc. in Minneapolis. Following heavy losses in 1985 and 1986, Control Data had shown recent signs of a turnaround. But the recovery stalled with a loss in the third quarter, largely due to disappointing results in Systems and Services' computer businesses. Control Data says that additional fourth-quarter losses could all but wipe out profits for the year. □

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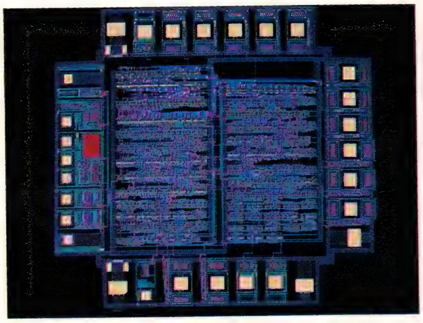

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EL1/89

Signetics 68070

Moto dives into RISC chip pool

NEW YORK—Motorola finally takes its plunge into the RISC pool today … announces its long-awaited … chip set. More … is

chip from a semiconductor manufacturer to find a place in the computer and workstation world. Major system companies are pushing the RISC theme with own architectures, shutting the door on standard products

Intel unveils long-awaite

Intel Corp. of Santa Clara unveiled on Thursday its long-anticipated 'P-9' computer chip, which will create less expensive personal computer systems that run more sophisticated software.

Introduction of the new 80386SX chip, which analysts say eventually will supplant Intel's widely used 80286 chip as the "brain" of certain IBM PC and compatible computers, essentially is a marketing move that allows computer makers to offer lower-cost alternatives in their high-powered 80386-based product line.

For example, prices o… puters—like the IBM … 80286—range from … $4,500. Systems bas… like the IBM Mod… chip—start at ab…

The 80386SX … all the software of … —although more slow…

The new chip also w… 8086 software, Intel said.

While analysts said they expe…

Advanced Micro Devices positions its 29K for the embedded micro mar

AMD, with its new 29000 mi… bably the most recent … ed co… are…

ner 386

… to rep… the 80286 chip in many … they also … the huge market … machines, par… larly lower- … ish. … han 10 million 8028… directly upgrade … SX chip. But … called … can … els

N… 32 micro now supported by fast coprocessor control chip

Although National Semiconductor's NS32532 microprocessor has a dedicated math coprocessor (the NS32381), its 1-MFLOPS floating-point calculation speed is deemed too slow for many tasks. To meet speed demands, National came up with the NS32580, a dedicated coprocessor-control chip that ties Weitek's WTL3164 fast floating-point data path in the 32-bit 32532 microprocessor. The combination yields a peak floating-point performance of 15 MFLOPS for single- and double-precision tasks.

Now, what about the other 95% of your design?

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Signet 27HS641
Marks Entry Into
CMOS EPROM Market

SUNNYVALE, CA, May XX, 1988—Signetics today announced its entry into the High Performance segment of the CMOS EPROM market with the unveiling of an 8K x 8 device that offers bipolar speed and CMOS low-power performance at competitive pricing.

"Our part is one of the fastest of its kind on the market," said Terry Leeder, vice president and general manager of the Application Specific Product division for Signetics. "And Signetics has the added advantage of being the only high-volume producer to introduce this type of device."

Signetics Single Port
1Mbit DRAM Controller
Handles 40ns Access DRAMs

SUNNYVALE, CA, May 23, 1988—Signetics announced today a new series of 1Mbit dynamic RAM controllers that offer synchronous single- and dual-port operation at 100MHz—providing arbitration, signal timing and refresh address generation for DRAMs up to 40ns.

The 74F1764 and 74F1765 are recent addition to Signetics FAST logic family, and e extensions of the 256Kbit versions, the 74F764 and 74F765. The 74F1 64 differs from the 74F1765 only in that it has an on-chip input address latch—a useful feature for systems that employ unlatched or multiplexed address and data buses.

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is an asynchronous designed for high-speed applications. The priority of arbitration is determined on a first-come-first-served basis. Separate "Bus Grant" outputs are available to indicate which one of the request inputs is served by the arbitration logic. All "Bus Grant" outputs are enabled by a common enable (EN) input. In order to generate a bus request signal, a separate 4 input AND gate is provided. This may also be used as an independent AND gate.

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PRODUCTS TO WATCH

GAZELLE'S NEWEST PROGRAMMABLE LOGIC DEVICE IS AS FAST AS . . . A GAZELLE

Targeting the high clock rates of next-generation complex- and reduced-instruction-set processors, Gazelle Microelectronics Inc.'s latest gallium arsenide programmable logic device runs at 95 MHz. That compares with 33 MHz for the fastest equivalent user-programmable silicon devices. The GA23S8 is laser-programmed at the factory to create a hard-wired logic circuit that is 100% TTL-compatible. It incorporates six buried registers, eight output-logic registers, and 128 logic product terms in a 20-pin package. Typical propagation delay through the device is 7.5 ns. Setup time is 4 ns and clock-to-output time is 6.5 ns. The Santa Clara, Calif., company is pricing the GA23S8 at $43 each in 1,000-unit quantities. □

INTEL MODEM CHIPS MOVE COMPRESSED DATA AT 4,800 BITS/S

Data compression and error correction using the Microcom MNP Class 5 protocol—which dramatically boosts modem throughput—can now be implemented in hardware with Intel Corp.'s 89C024XE chip set for 2,400-bit/s modems. The Santa Clara., Calif., company's two CMOS chips also implement all standard modem functions, including the command set developed by Hayes Microcomputer Products for its smart modems. Data compression can run at up to 4,800 bits/s. The analog front-end chip handles two- or four-wire telephone interfaces, digital-to-analog and analog-to-digital conversions, and filtering. The other chip, a 16-bit microcontroller, does all the control and digital signal processing. The chip set conforms to the Bell 103 and 212A standards as well as the CCITT V.21, V.22 A and B, and V.22 bis standards. The sets are priced at $40 each in 1,000-unit quantities. □

NCR DELIVERS A SINGLE-CHIP INTERFACE TO IBM'S MICRO CHANNEL

Building interfaces for peripherals that plug into IBM Corp.'s Micro Channel personal-computer bus will be easier and more efficient with NCR Microelectronics' single-chip CMOS solution. The 86C01 bus interface replaces up to seven integrated circuits now needed for the job, says the Dayton, Ohio, company. A high-performance adapter for the Small Computer Systems Interface can be implemented for $25. The 86C01 supports 8- or 16-bit peripherals and boasts an up-to-3-Mbyte/s data-transfer rate. Selectable input/output addresses on the chip allow peripheral cards to be easily relocated in the PC. The chip's architecture is optimized for easy integration with NCR's peripheral devices such as SCSI controllers, graphics adapters, and Arcnet local-area-network chips. The chips are available now at a price of $13.95 each in 1,000-unit quantities. □

OPEN-ARCHITECTURE ANALOG-DIGITAL TEST SYSTEM DEBUTS

Delta Information Systems Inc. says its STAR 2010 is the industry's first analog-digital test system based on an open-architecture design instead of a proprietary solution. The Horsham, Pa., company's STAR 2010 (for Standards-based Test and Analysis Resource) uses an IBM Corp. Personal Computer AT or compatible as its platform and other off-the-shelf hardware and software components for analog-digital testing of audio-frequency printed-circuit boards, subassemblies, and systems. A 68020 microprocessor is the test-system controller. It runs the OS-9 operating system for real-time control of test resources. The controller and test resources all reside in, and communicate through, a 21-slot VMEbus chassis. The basic STAR 2010 comes with a 64-channel digital input/output card; a 12-bit, 16-channel a-d card; and a 12-bit, 16-channel d-a card. In its basic configuration, the STAR 2010 is priced at $55,000. □

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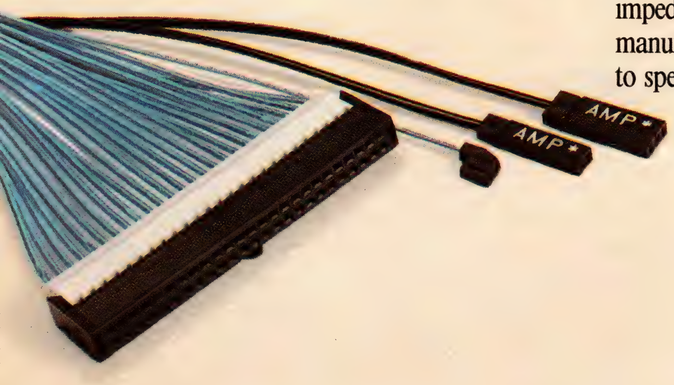

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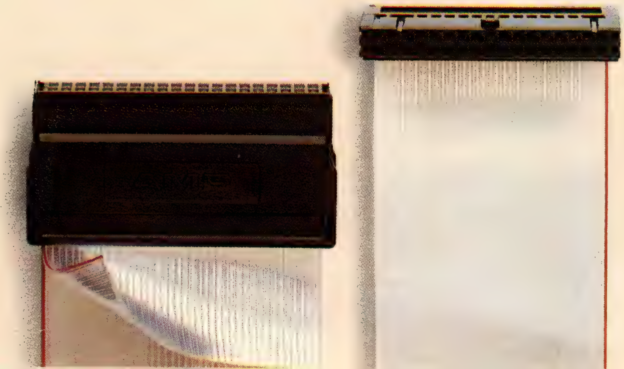

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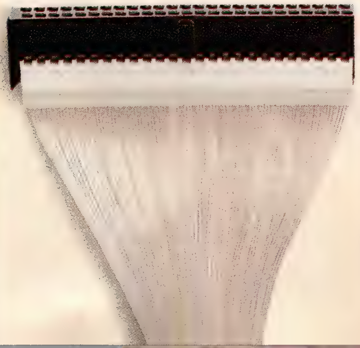
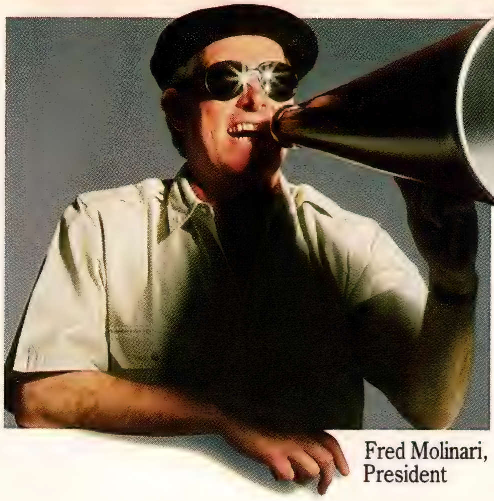
AMP Interconnecting ideas

Circle 25





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COULD THIS BE THE FACTORY OF THE FUTURE FOR LOW-VOLUME CHIP PRODUCTION?

TI project may change military IC processing—and there could be commercial fallout

TI's Heilmeier sees "environments less stringent than those projected for conventional [fab] approaches."

DALLAS

Armed with a five-year, $112.5 million cost-sharing contract from the Pentagon, Texas Instruments Inc. is out to develop the factory of the future for military microelectronics. The Air Force and the Defense Advanced Research Project Agency will put up about $75 million and TI will provide the rest.

The Dallas company was the sole contract winner late last year in the Defense Department's extremely aggressive program in Microelectronics Manufacturing Science and Technology [*Electronics,* Sept. 3, 1987, p. 31]. If the high-risk MMST effort achieves even a portion of what Pentagon brass are hoping for, the result could be nothing less than a fundamental change in the way that military integrated circuits, microwave devices, and infrared sensors are manufactured. What's more, there could be some fallout to the commercial sector along the way. And the cost of building a state-of-the-art semiconductor factory could drop significantly.

TI beat out 20 other bidders—mostly teams—with an approach that involves putting what amounts to a clean room into the equipment, rather than vice versa, and doing multiple process steps with the same equipment. "The TI proposal was very innovative. I'd almost put it out there in the revolutionary approaches to processing," says Gary L. Denman, deputy director of the Air Force Wright Aeronautical Laboratories. The effort will be managed by a Joint Program Office in the Electronic Technology Laboratory at Wright-Patterson Air Force Base near Dayton, Ohio. Unlike the Sematech research consortium, which will concentrate on high-volume memory-chip production, MMST is aimed at the military's unique set of needs. The effort will focus on extreme flexibility, with quick turnaround on low volumes of many different device types.

QUICK-TURNAROUND LINE. The MMST contract calls for TI to demonstrate by 1993 a fully integrated pilot fabrication line that can provide less than a three-day turnaround on more than 1,000 designs per year, with a throughput of 800 wafers per month. Minimum device geometries are to be less than 0.5 μm, probably around 0.3 μm initially. What's more, the line should be readily able to mix and match technologies, with concepts and equipment equally applicable to silicon, gallium arsenide, and mercury cadmium telluride devices.

To meet MMST goals, TI is taking a radically unconventional approach to the concept of chip manufacturing. "There are really two philosophical points of departure here," explains George Heilmeier, TI's chief technical officer and senior vice president. "One is that instead of putting equipment into clean rooms, you put the clean room into the equipment. In other words, no Class 1 [ambient] clean room is required." The second point, he says, "is that instead of moving the slice [wafer] to the process, you move the process to the slice. And that implies that you do multiple process steps with the same piece of equipment."

In MMST, TI plans to replace traditional semiconductor batch-processing equipment—such as diffusion furnaces—with equipment that handles a single wafer at a time. Wafers will be held in a controlled atmosphere from start to finish, with machines housing several vacuum chambers and performing various in-situ processing steps, all under closed-loop control to produce high first-pass yields.

If TI succeeds, the effort could lead to microelectronics factories that are 10 times cheaper to build than those based on conventional techniques, Heilmeier says. "It's very popular to think that the way ICs will be manufactured in the future is in clean rooms that don't have any people in them, just robots," he notes. And that's an expensive proposition.

But TI's proposal offers an alternative. Since wafers will be held in a controlled atmosphere throughout, "you're talking about environments for the equipment that are much less stringent than those projected for conventional approaches," says Heilmeier. "As we've gotten to smaller and smaller line widths, it's clear that we need better clean rooms," adds Denman. "One of the key drivers that motivated us in the first place was to solve the problem of the cost of clean rooms going through the roof."

HEAD START. At the DOD's urging, TI will bring in some subcontractors—primarily equipment vendors, who will get a head start on whatever new processing gear is developed. "There will be points along the way where we will be sharing the results of this government-funded activity with industry," says Denman.

Although many MMST concepts may not be applicable to high-volume manufacturing, Denman sees "high potential for commercial spin-outs" in lower-volume niche markets. "I don't know what the impact might be on the commercial side right now," says TI's Heilmeier. "But I know that if we are successful, it's going to have a tremendous impact on the military." *–Wesley R. Iversen*

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IS FUJITSU'S NEW MACHINE REALLY A TROJAN HORSE?

TOKYO

Is Fujitsu Ltd. trying to pull a fast one? That's one way wary U. S. supercomputer watchers explain the fact that the Tokyo company's newest supercomputer family has fallen considerably short of their expectations.

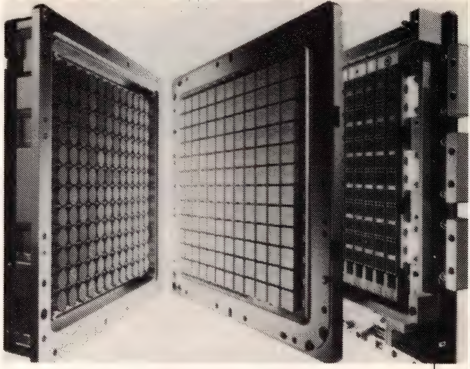
The only surprise in last month's announcement by Fujitsu of its VP2000 Series was that it underwhelmed rather than overwhelmed the industry. It was not the bombshell machine expected from the giant computer maker. Rumors had been flying around that both Fujitsu and its rival, NEC Corp. of Tokyo, were about to offer supercomputers that would, for the first time, force potential users in the U. S. to sit up and take notice. But the VP2000 is not that kind of machine, and it appears unlikely to break its way into the U. S. market.

So what is Fujitsu up to? "I don't think it is their real machine," says Gary Smaby, managing director of Needham & Co. in Minneapolis and an expert on the industry. "It's a Trojan horse machine, behind which there may be ulterior motives; perhaps it was announced to preempt a pending announcement from NEC." And the new machine also may offer a peek at Fujitsu's next-generation mainframe.

NOT THE ONE. Feeding the Trojan horse theory are the bits and pieces of information that the industry has been gnawing on, stories of a machine under development at Fujitsu that is much more exciting and powerful than the VP2000. "This is not the machine we've been hearing about—eight processors, HEMT technology, and delivering more than 5 gigaflops," says Smaby.

Add to that the fact that the Japanese computer companies all know that they will have to go to parallel architectures for their top-performance machines, and it's easy to conclude that this uniprocessor system is a stopgap.

But whatever Fujitsu's strategy, the VP2000, at 4 billion floating-point operations/s for a single processor, is a significant achievement. However, the machine is just a little faster in specified peak performance than the other high-end supercomputers from Cray Research, Control Data's ETA Systems division, and Hitachi. The Cray Y-MP's peak rating of 2.4 to 3.6 Gflops and the single-processor Hitachi S-820's 3 Gflops are not far below the VP2000, and the ETA 10-E's 6.9 Gflops surpasses the VP2000.



VP2000's guts: (from left) connector module, pc substrate, heat-conduction module.

The competing machines are available now, but the Fujitsu machine in its biggest and fastest configuration—the 4-Gflops VP2600/20, with one vector processor and dual scalar processors—will not be delivered until 1990. By that time Cray will be delivering its follow-up to the Y-MP as well as the Cray 3. Both will probably outperform the VP2000.

Another piece of the puzzle is that the VP2000 may have hidden within it a preview of Fujitsu's next mainframe computer, designed to beat IBM Corp.'s next mainframe, the so-called Summit. After all, the new machine, with its scalar-processor design, has 50% more processing power than Fujitsu's present top-of-the-line M-780 mainframe. A spokesman from one of Fujitsu's Japanese competitors believes that the slightly modified scalar processor will become the central-processing unit of Fujitsu's next-generation mainframe.

The spokesman also believes that Fujitsu is understating the true power of the new computer for two reasons. One is that it doesn't want to give IBM a fixed target to shoot at. The other is that in little more than a year Fujitsu will be rolling out another supercomputer featuring exotic devices built for a project for the Japanese government. Fujitsu thus has to announce sufficient performance in the commercial machine to wow potential customers while leaving enough margin for the experimental computer to satisfy the government. Then, when competition requires additional performance from the commercial system, Fujitsu will be ready with a quick response.

There is a precedent for supercomputer hardware that soon afterward shows up in a mainframe. The front-end processor in NEC's SX-2A supercomputer used the same architecture and provided the chips for NEC's ACOS-1500 mainframe. Although the scalar processor in Fujitsu's new supercomputer and the front-end processor in NEC's supercomputer don't have the same function, one can be uncoupled and used as a front-end processor. *–Tom Manuel and Charles L. Cohen*

EUROPEAN COMPANIES CATCH ACQUISITION FEVER

NEW YORK

After sweeping through corporate America for the past seven or eight years, acquisition fever is spreading to the electronics industry in Europe. But unlike a lot of the U. S. companies struck by the urge to merge—which often seem interested mostly in financial wheeling and dealing—the European firms appear to have solid business reasons for the moves they're making.

The two latest deals to be announced bear this out. In fact, for the buyers, both acquisitions—the purchase by West Germany's Siemens AG of a considerable portion of IBM Corp.'s telecommunications unit, Rolm, and the proposed acquisition of Inmos Ltd. by the French-Italian combine SGS-Thomson Microelectronics SpA from Great Britain's Thorn EMI plc—serve similar purposes.

In the Siemens-IBM deal, Siemens gets entry to the U. S. private-branch-exchange market, more sales muscle in Europe, and much stronger PBX production capability. Of the three, the access to a new American market is probably the most important—Siemens plans for a significant portion of its future growth to come in the U. S. For SGS-Thomson, the proposed Inmos acquisition would mean gaining a 32-bit processor—the transputer. A 32-bit chip is one of three steps the company sees as vital to its goal of becoming a top-10 semiconductor company; the other two are a dynamic random-access-memory product line and access to Japan's systems markets. As Siemens looks to the U. S., SGS-Thomson looks to Japan.

Siemens, SGS-Thomson both make deals to build strength in key markets

The Siemens-Rolm deal is the more complex of the two. The financial terms of the agreement weren't disclosed, but it involved more than Siemens simply buying Rolm outright. The West German company did buy most of Rolm's manufacturing and development operations, which will be combined with Siemens telecommunications manufacturing and development centers that are already operating in the U. S. The combination will form a new Siemens subsidiary, Rolm Systems Inc. Another subsidiary will be set up to sell Rolm equipment in the U. S.; that subsidiary will be a joint venture with IBM, staffed by Rolm sales and marketing people, with each company owning half the operation.

In addition, IBM will stop selling Rolm PBXs in Europe. It will start selling a PBX made by Siemens that will carry the IBM logo.

For Siemens, the deal considerably strengthens its telecommunications position in both the U. S. and Europe. In the U. S., it teams Rolm's highly respected production staff with Siemens' own production people, and it reenforces Siemens' U. S. sales and marketing with more than 5,000 Rolm employees.

In Europe, the deal not only removes the competition by IBM but puts the former competitor to work selling Siemens equipment. Adding the continent-wide IBM sales staff to its own should make Siemens the leading PBX supplier in Europe. (It now ranks just behind France's Alcatel NV communications group.)

And Siemens won't stop here. "In the U. S., we haven't reached cruising altitude yet," says Karlheinz Kaske, the company's chief executive officer. "We're still in the climb phase."

The acquisition of Inmos could be just as important for SGS-Thomson. The agreement is in its preliminary stages; financial terms are still being worked out. But what SGS-Thomson will mainly get is the transputer. Adding a 32-bit chip to its product line is one of three key steps that SGS-Thomson must take in its drive to become one of the world's top semiconductor makers, according to Pasquale Pistorio, the company's chief executive officer and president. "Inmos has a lot of nice things, such as fast static RAMs, but the transputer is the main area of interest," he says.

The acquisition does not, however, mean SGS-Thomson is dropping out of or competing with the Europrocessor project, a combined effort by several European companies to develop a 32-bit microprocessor [*Electronics,* December 1988, p. 29]. The transputer is a 32-bit chip built specifically for parallel-processing applications, says Phillipe Geyres, corporate vice president of SGS-Thomson. The Europrocessor effort is aimed at a general-purpose processor, something SGS-Thomson still needs.

Two other measures Pistorio says his company needs to take are developing a 1-Mbit dynamic RAM, with a fast path set up toward development of a 4-Mbit DRAM, and establishing a strong presence in Japan. "By the end of the first quarter in 1989, we will identify how we will deal with those issues," Pistorio promises.

–Larry King

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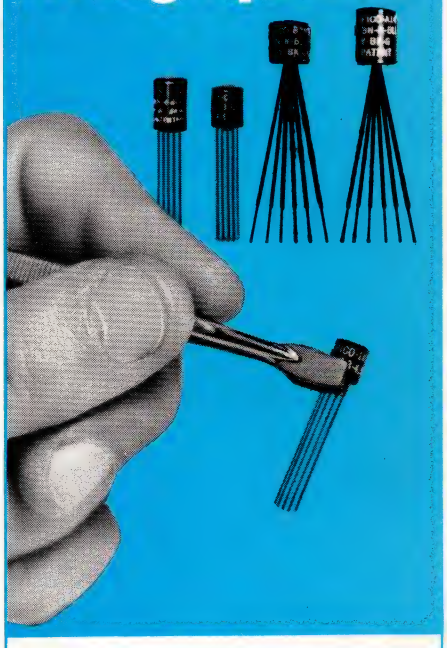

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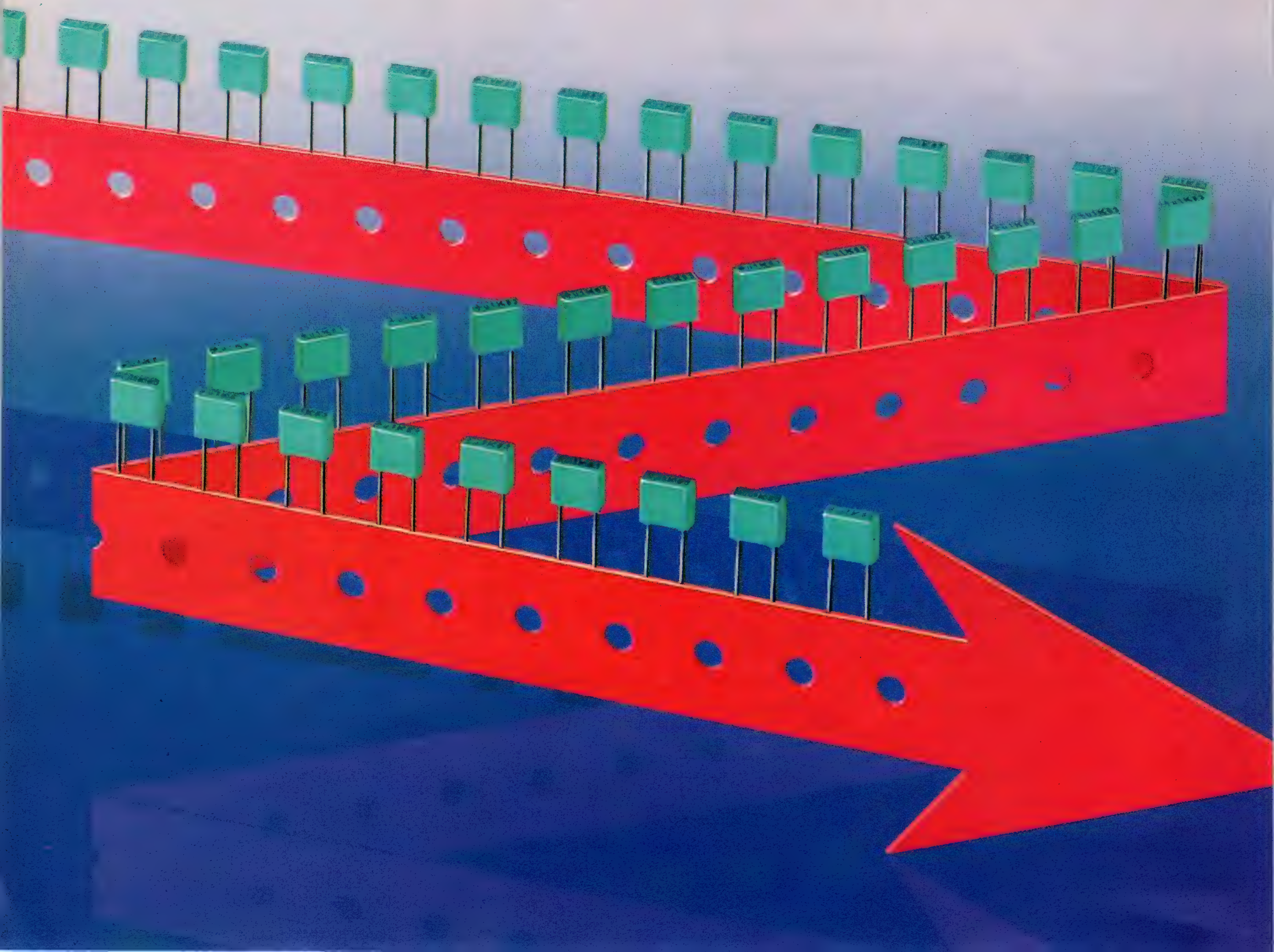

IMAGE PROCESSING

WHY AN ADD-IN BOARD FIRM IS PLUNGING INTO CHIPS

MARLBORO, MASS.

Data Translation Inc. is doing well as a vendor of computer add-in boards. So why is it getting into the risky, volatile chip business? Because the Marlboro company was looking around for a business move that would enable it to take a step up in growth, and it decided semiconductors made a lot of sense.

The company already has substantial expertise in semiconductor design, because it couldn't find the chips it needed for its boards and went ahead and developed them itself. As a result, it has a healthy product line of proprietary chips that meet market needs.

The chips go into Data Translation's data-acquisition and image-processing boards for various computer buses. For its first commercial semiconductors, the company has chosen three CMOS devices now being fabricated by LSI Logic Corp. in Milpitas, Calif. Others will follow.

Two of the three chips convert red, green, and blue signals to values of hue, saturation, and intensity for more efficient color-image processing. The third implements the interface to the IBM Corp.'s Micro Channel personal computer bus.

At least at first, the RGB-to-HSI converter chips look like the best market bet. Company executives say they know of no other chips that implement the RGB-HSI conversion algorithms, which greatly speed color-image processing using a personal computer. The devices are proven technology: Data Translation already uses them in its DT2871 frame-grabber board for the IBM Personal Computer AT [*Electronics,* Jan. 7, 1988, p. 40]. The chips will sell for $63 each in lots of 1,000.

BUS INTERFACE. The Micro Channel interface chip, the DT7920, contains most of the bus-interface circuitry required for IBM Personal System/2 Micro Channel add-on boards and peripheral controllers. Packaged in an 84-pin plastic leaded chip carrier, the chips are priced at $31 each in quantities of 1,000.

Unlike the converter chips, though, the device is not the only one in its market niche. Data Translation's Richard Pleau, product marketing manager, figures the strongest competition will come from Standard Microsystems Corp. in Hauppauge, N. Y., and Capital Equipment Corp. in Burlington, Mass. Other contenders are Altera Corp. in Santa Clara, Calif., and Chips & Technologies Inc. in San Jose, Calif.

Another factor is the slowly developing market for Micro Channel add-in boards, the makers of which will be the customers for the interface chips. Until recently, relatively few boards were getting to market, mostly because of the design challenge PS/2 circuit boards present—they're 43% smaller than those used in the PC AT. That is beginning to change; about 500 Micro Channel boards are now available. "We want to help with that process by making it easy to interface with the Micro Channel," Pleau says.

One of his foremost competitors, however, wonders whether Data Translation is really going into the business of selling the interface chips on a large scale. The company might simply be trying to get a return on a substantial chip-design investment, says Kerry Newcom, president of Capital Equipment, which sells an interface chip and a design kit to assist Micro Channel board builders.

Pleau says Data Translation certainly is taking advantage of a $250,000 silicon design-and-simulation capability. But he insists it is going beyond a short-term foray into chips. "These are just the first chips we're offering," he says. "More will come." *–Lawrence Curran*

TEST EQUIPMENT

A BATTLE IS BREWING IN ASIC VERIFIERS

SAN JOSE, CALIF.

There's a battle shaping up in low-end verification systems for application-specific integrated-circuit prototypes—and it's over performance. Hewlett-Packard Co. and Tektronix Inc. are betting that there's a market for higher pefor-mance at a price somewhat higher than those of other low-end systems.

On Jan. 1, Tektronix was set to introduce its LV500, and on Jan. 2, HP to debut its HP82000 Model D50. Both provide 50-MHz clock rates, performance that until now has been restricted to high-end verifiers. The LV500 will start at $55,000 and the D50 will begin at $70,000.

A number of other vendors, notably Cadic, HiLevel Technology, and Integrated Measurement Systems, introduced ASIC verifiers with prices below $25,000, but they cut performance to drop their prices. None of these lower-priced models provides clock rates greater than 30 MHz.

Now the big question is who'll win a greater share of the designer's dollar: the 30-MHz-and-below camp or the HP-Tek-

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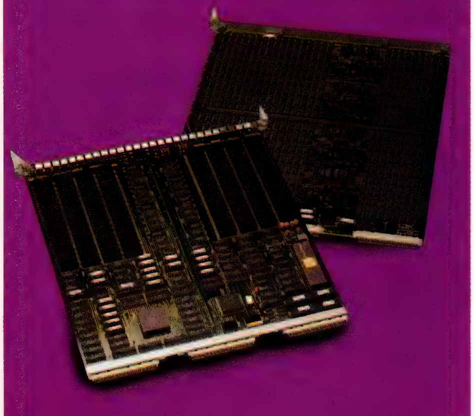

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tronix camp. All this low-end activity could greatly expand the market for ASIC verifiers. These testers do not now make an enormous market. *Electronics'* annual forecast (see p. 79) puts it at $35 million in 1987, growing 43% to $50 million in 1988 and 50% to $75 million in 1989. "The ASIC verifier has never really attracted the design engineer," says Cindy Thames, vice president at market researcher Technology Research Group in Boston, Mass. "The systems tend to be used in testing applications as lower-cost alternatives to high-end component automatic test equipment, not for debugging ASIC devices."

For component testing, the high-end ASIC verifiers may have been a low-cost alternative to other ATE. But they still can cost in excess of $500,000. That's the reason for the spate of activity at the low end. It's also the reason for the sharp difference in performance levels—and prices—in the new verifiers.

"ASIC designers need enough performance to ensure the part operates functionally and if not, to perform 'what-if' analysis to determine what's wrong," argues Garth Eimers, vice president of marketing at Cadic Inc. in Beaverton, Ore. "Also, the engineer wants to establish rough operating margins for his design, but not perform true characterization. As a result, he needs less stringent timing accuracy." That's why Cadic introduced its $25,000, 120-channel system 6000 late last year. It operates at 25 MHz, with a timing accuracy of ±3 ns.

At least two other tester makers side with Cadic, although they offer better accuracy. The 30-MHz Topaz FX, introduced in mid-1987 by HiLevel Technology Inc. in Irvine, Calif., starts at $25,000 for 48 channels and provides a timing accuracy of ±1 ns. The two-year-old entry-level 20-MHz LogicMaster ST from Integrated Measurement Systems Inc. in Beaverton comes in at $16,000 for 16 channels and hits ±1 ns.

That performance isn't sufficient for the burgeoning breed of 20-to-50-MHz ASICs, says Keith Corbett, HP marketing manager in Böblingen, West Germany, where the model 50 was developed. He says a market study showed that for buyers, timing accuracy is second in importance only to the link between design and test.

That's why the 50-MHz HP model D50, which starts at $70,000 for a 16-channel system, boasts a ±500-ps timing accuracy. "The spec is only slightly less than the ±250 ps found on the high-end Model 200," says Mathias Stahl, product manager for HP in Böblingen. A 256-channel model costs $240,000.

LESS ACCURACY. The new 50-MHz Tektronix system will come in at an even lower price—$55,000 for a 64-channel version—but it has a lower overall timing accuracy of ±2 ns. The price of a 256-channel system will be $172,000. "The key to this instrument is its price/performance combination," says Kenneth Panck, business unit manger at Tektronix in Beaverton. "We believe that in achieving low cost, we made the correct trade-offs in performance." As for the ±2-ns timing accuracy, Tektronix says it measures this spec much more conservatively than do other manufacturers.

One way both Tektronix and HP lowered costs was to heavily integrate the test-head electronics. In the LV500, there is one board under the test head with 16 ICs for a fully configured system. Each IC contains all the pin-driver electronics for 16 channels. Eight other ICs perform all the timing generation.

And the HP unit "has 16 channels per board," says David Armstrong, U. S. marketing and support manager for the product line. For its system, the company developed an integrated pin-electronics chip and a highly integrated timing and formatting chip.

–Jonah McLeod

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CAE

'PIRAMID' COMPILER SLASHES IC DESIGN TIME

EINDHOVEN, THE NETHERLANDS

Searching for ways to cut the time it takes to design integrated circuits, a team of European researchers has developed a silicon compiler that can reduce design time "from a few months to a matter of days or even hours." That's the word from Engel Roza, a researcher at Philips International NV and the head of the compiler project, devised by Philips Research Laboratories in Eindhoven, the Netherlands, along with the Interuniversity Micro-Electronics Center (IMEC) in Leuven, Belgium.

Called Piramid, for Precompetitively Inspired Research on Advanced Methods for IC Design, the compiler is based upon a target architecture that is customized during the compilation process. It saves time by taking on important jobs that other silicon compilers aren't sophisticated enough to handle. For example, Piramid translates a description of the behavior of the chip to be designed into a system architecture with large functional modules such as random-access memories, arithmetic logic units, and the like. The modules' parameters are not fixed, so the architecture is flexible and can be used for different applications.

Depending on the application, Piramid can then generate solutions. Usually, the electrical design of the architecture is done manually—a laborious and time-consuming chore. "Piramid is not intended to replace the human designer," says Gef van Meerbergen, senior researcher at the Eindhoven labs involved in the project. "Rather, it is to give him the possibility of exploring a variety of architecture alternatives."

AS USUAL. After Piramid has translated the chip behavior into a chip architecture, the compiler proceeds in pretty much the same way as does a conventional one, Roza says. The modules are automatically detailed by fixing their parameters and retrieving designs for them from a library. Piramid contains the tools for synthesizing the architecture and for translating it into a concrete silicon design.

Piramid is based on a concept developed in a project for Esprit, the European Strategic Program for Research and Development in Information Technology. That concept is called Cathedral II and was developed by IMEC as prime contractor in partnership with Philips, Belgium's Silvar Lisco, France's Alcatel NV, West Germany's Siemens AG, and the University of Bochum, West Germany.

The Piramid compiler itself was designed primarily for digital-signal-processing applications at low and medium speeds; that is, for designing circuits to be used in telecommunications and consumer-electronics products. It was built by Philips, which is already using Piramid to help design a single-chip compact-disk system.

Piramid integrates three separate compiler environments: synthesis, floor-planning, and module-generation. They are supported by a powerful cell library.

The synthesis environment translates a high-level behavioral description into a system structure. This is an interactive process. For guiding it, the module-generation environment can be consulted. This allows users to call procedures that give accurate feedback on area and timing views in an early stage of the design process.

At the end of the synthesis process, the final structure, including the selected parameters, is sent to the floor-planning environment. This environment accepts the structure and tells the module-generation environment to generate black-box views of the modules. Then the net assignment, placement, and global and detailed routing are performed. Next, the module-generation environment is told to produce detailed layout views. These are assembled with the layout to generate a complete chip.

Users can command the module-generation environment in a procedural way. It can generate several views of the modules such as detailed layout, black-box information, timing, area, test view, and functional view. Leaf cells can be designed using symbolic layout and compaction. These cells are integrated in a procedural way to create greater units. In this way a flexible library can be generated, one that can easily be adapted to changes in the layout rules. *–John Gosch*

POCKET COMPUTERS

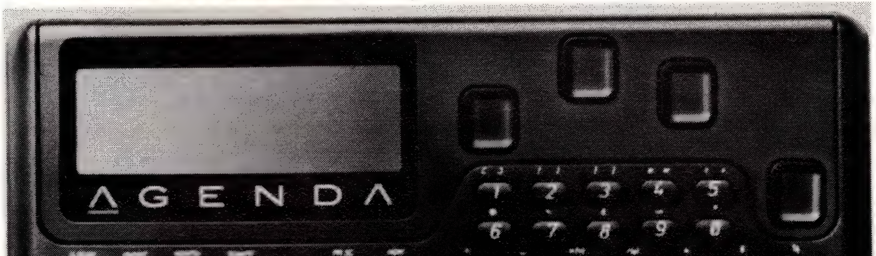
SMALLER THAN A LAPTOP—HERE'S THE POCKET COMPUTER

MITCHAM, ENGLAND

In the drive to take computing the next logical step down from laptops, Microwriter Systems Ltd. of Mitcham in Surrey, England, has used every trick in the book. The company's new pocket-size computer, called Agenda, uses surface-mount technology throughout. An application-specific integrated circuit forms the glue logic around its Hitachi 6303 processor and its 320-Kbyte internal memory. Battery-backed, removable random-access-memory cards make up the data-storage unit. The result is a computer that measures just 175 by 85 by 18 mm—the same size as a pocket diary.

The innovation Microwriter is counting on to give Agenda an edge over its competitors, though, is a specially developed keyboard known as the Chord keyboard. It occupies an area about 3.5 in. by 4 in. and consists of just five keys, one for each fingertip, arranged in an arc.

Each letter of the alphabet is formed by pressing different combinations of these five keys, says Microwriter managing director Mike Davies. "Our biggest problem was developing a mechanism for the keyboard that provides the correct tactile response with pressures of less than 20 grams," he says. As with Morse code, the keyboard is configured so the most frequently used characters are formed by hitting the simplest combina-



Agenda is a full-fledged computer with word-processing, data-base, and diary functions built into a package the size of a pocket diary.

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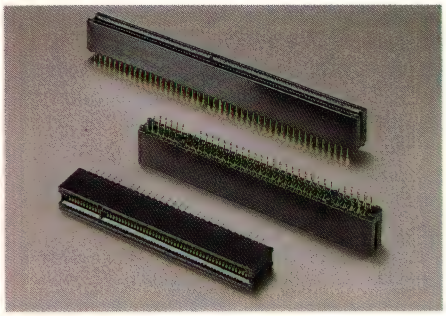
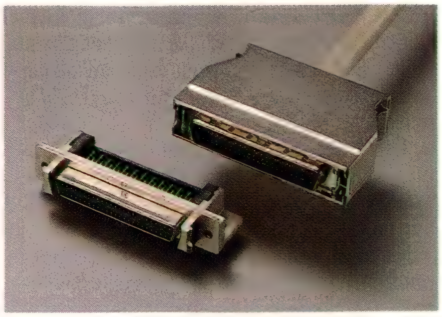
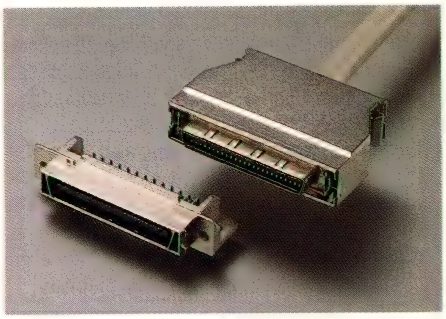


Card-edge connector (FCN-220)



SCSI-II PCB-to-cable (FCN-230)



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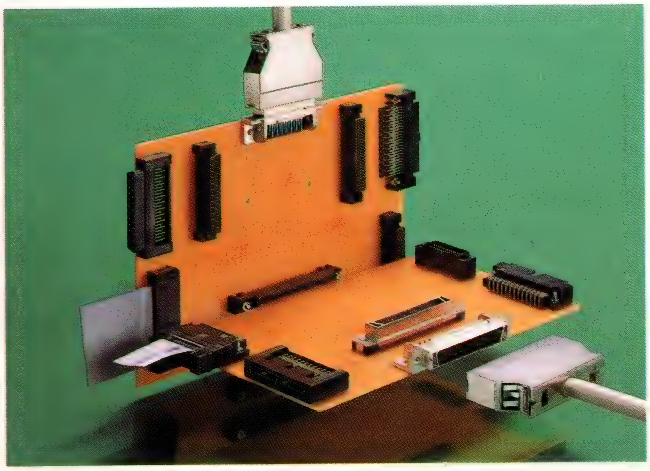

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tions of keys. The letter "E," for example, is made simply by pushing the forefinger's key alone, and the letter "S" by pushing the third finger's key alone. The letter "Z," however, requires hitting the keys for the thumb, middle, and little fingers simultaneously. "It sounds complicated," Davies says, "but most people become proficient in less than 20 minutes, and an accomplished user can type with one hand at around 50 words a minute."

The machine also has a conventional, albeit very small, alphanumeric keyboard. Another 30 buttons select functions from the machine's built-in word-processing, data-base, and diary software.

The machine uses a liquid-crystal display showing four lines of 20 characters. Power is from rechargeable NiCad batteries.

Internal software is held in a 32-Kbyte read-only memory. Third-party software on RAM cards will be available shortly, Davies says. The first externally loadable software will be a Basic compiler and an XModem communications protocol converter, to allow the interchange of binary files with other machines.

Compatibility with desktop computers and printers has been provided for with both RS-232 serial and Centronics parallel data ports.

The machine is listed in the UK at $250. Additional 32-Kbyte RAM cards cost around $50 each. *–Peter Fletcher*

TELECOMMUNICATIONS

JAPANESE TELECOM MAKERS EYE EUROPE

TOKYO

Japanese manufacturers of telecommunications equipment are keeping their eyes on the coming barrier-free Europe, where so far what they have seen is mostly hope and promise.

Competitors worldwide are maneuvering for the big push in 1992, when the European Community is scheduled to eliminate tariffs [*Electronics,* November 1988, p. 81], and Tokyo's telecom legions are eager to realize what for them has been tantalizing promise. The problem has been that except in England, access to European telephone systems is restricted, making it difficult to sell subscriber equipment. And the PTTs—the government-operated telecom authorities—show little inclination to buy transmission and switching equipment from Japanese companies.

The Japanese acknowledge that Europe has been a difficult market for them but feel that the advent of integrated services digital networks will provide a playing field with everybody starting fresh. The consensus is that by 1992 ISDN will shake down to a worldwide standard. "With the increase in demand for communications it will be necessary to use ISDN superhighways rather than conventional roads," says Tsuneo Hara, general manager of the telecommunication marketing division at Canon Inc. in Tokyo.

England, France, Italy, and West Germany are installing switches for digital transmissions as they move toward ISDN, says Akira Miyazawa, vice president of NEC Corp., and Japanese companies are planning to build terminal equipment for the market even though they have no indication yet of how the PTTs might treat them in the future.

NEC LEADS. But for now, the roadblocks are still in place. NEC is the most successful Japanese manufacturer in Europe, and its sales of telecom equipment there amount to only 1.3% of its total sales of $17.6 billion. In addition, telecom sales are growing at a rate of only 10% a year, considerably slower than those of consumer products, computers, and chips.

The best market is the UK, where British Telecom has been made private and the market is being liberalized. From its base in Telford, where its goal is to become an English manufacturer with Japanese capital, NEC Technologies UK Ltd. makes and sells cellular telephone sets. It also sells systems to the five Scandinavian countries. The company wants to play a role in the planned pan-European digital mobile system by setting up plants in other European countries.

Another Japanese company trying harder in Europe is Fujitsu Ltd. of Tokyo. Its sales in Europe rank considerably lower than NEC's, and the company maintains that it does no manufacturing on the continent. However, it owns 60% of a joint venture with Spain's Telefonica that turns out packet-switching exchanges and modems.

Its biggest success has been in Sweden where it sells fiber-optic transmission systems. Fujitsu systems cover two thirds of the country, but it splits the market 50-50 with L M Ericsson of Stockholm. Fujitsu also sells phones in Finland, cordless phones in Austria, facsimile machines in England and Spain, and private-label faxes in West Germany. "We must sell more, but there are political problems as well as the fragmentation of the market into small national markets," says Takao Ueda, manager of communications systems in the firm's international operation. *–Charles L. Cohen*

COMPANIES

IS PLESSEY SEEKING AN ALLY TO HELP THWART TAKEOVER?

LONDON

Plessey plc may be looking for an ally of its own to ward off a hostile takeover bid by General Electric Co. of Britain and Siemens AG. Executives at the British defense electronics giant say they have devised a number of strategies to frustrate the latest moves from GEC Siemens plc, the combine formed by GEC and the West German electronics and computer maker. They have already upset the timing of the effort by obtaining a restraining order.

Confident that they can thwart the takeover, the Plessey executives are waiting to see the documents presenting the formal offer before deciding which strategy to use. But industry watchers say one possible move would be to find a continental cohort, although the company probably won't go so far as to seek a "white knight" for a friendly merger. Among the potential allies, the French firm Thomson CSF is said to be Plessey's current favorite.

For the short term, though, Plessey's strongest ally may be the British Ministry of Defense. The ministry was instrumental in thwarting GEC's first bid for Plessey in 1986. And Stephen Walls, appointed to the post of Plessey group managing director only weeks before the new onslaught last month, believes the objections the ministry raised two years ago are still valid.

DEFENSE PLOY. At that time, the ministry was concerned that a merger would destroy competition for defense contracts. GEC has let it be known this time around that, if it wins control, Plessey's defense electronics business in the UK would be kept independent and would operate in competition with Marconi Electronics Ltd., Chelmsford, GEC's major defense subsidiary. But Walls maintains a merger would still tend to reduce competition in the UK.

Walls is also reported to be seeking moral support from the Pentagon. Washington is certain to have an interest in the deal, since GEC and Siemens plan to carve up Plessey's newly acquired North

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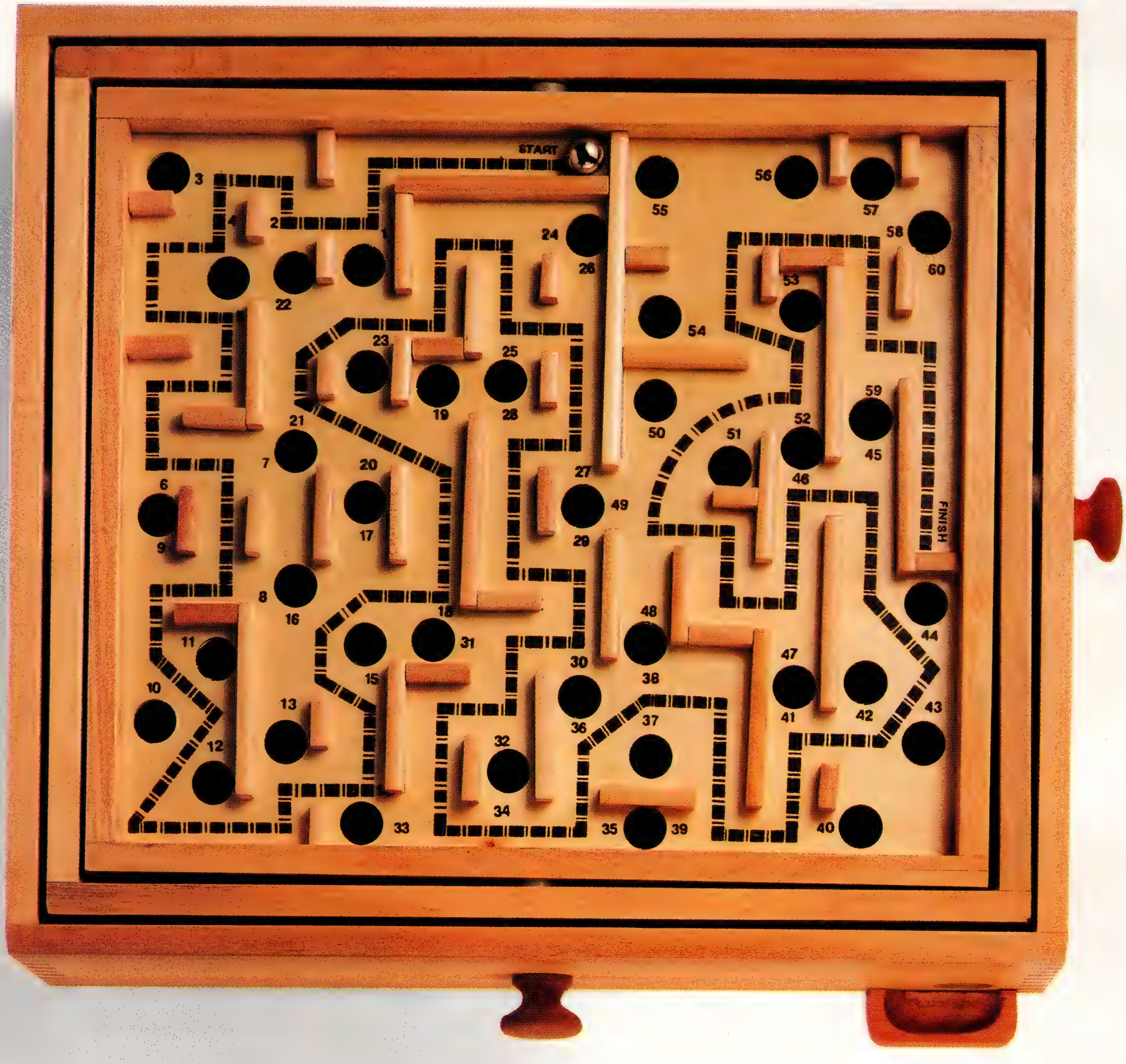

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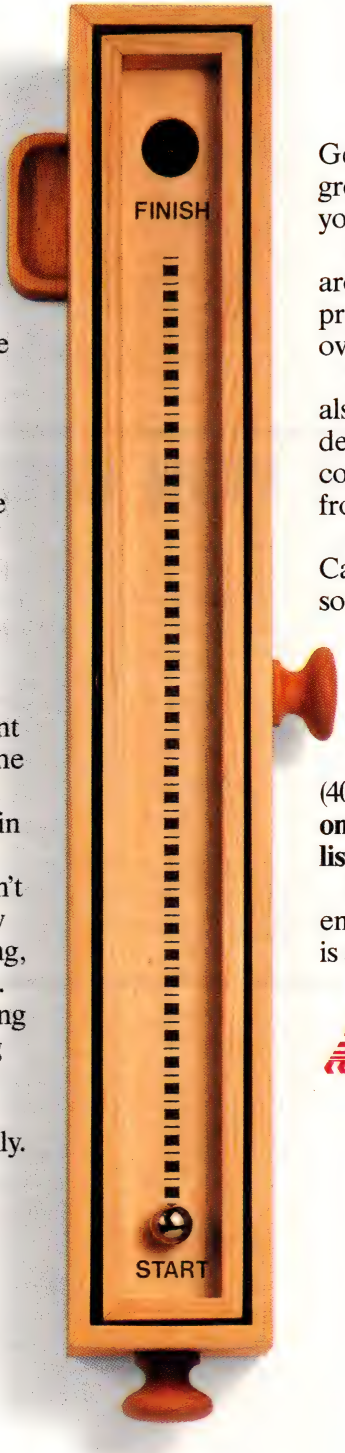

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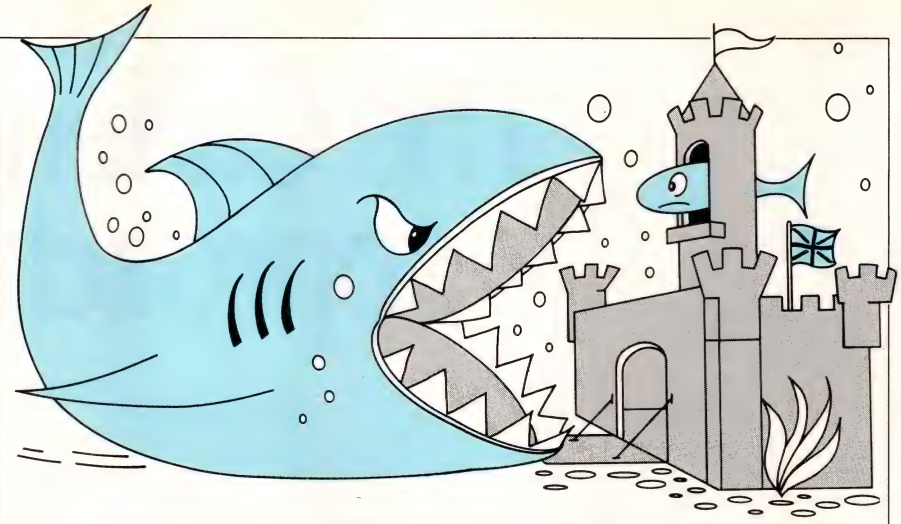

American defense electronics subsidiaries [*Electronics,* November 1988, p. 68]. Walls points out that Plessey had to make special arrangements to maintain independent managements for both Sippican Inc., Marion, Mass., and Plessey Electronic Systems Corp., Wayne, N. J., to allay Pentagon concern over the possible loss of control of sensitive projects that both companies are leading.

Plessey may also find support from the European Community. The EC might be persuaded that a combined effort by two of Europe's largest electrical and electronics corporations to acquire Plessey is anticompetitive. If either Siemens or GEC really wants to take control of the market, Plessey argues, then they should compete with each other.

There are opposing views, of course. Some factions in the Ministry of Defense reportedly strongly favor the deal. One line of reasoning supporting this view is the assumption that Sir Arnold Weinstock, chief executive of GEC, would not risk exposing his own reputation to a second rebuff without having first obtained at least tacit support from the ministry. A second theory is that the ministry sees advantages for itself in GEC's taking a 50% stake in Siemens' European defense electronics businesses, and that it likes the idea of the merger forming what amounts to an embryonic pan-European defense electronics group—one that would be able to offer the lower costs accruing from economies of scale.

In the meantime, the Plessey defense team is getting ready for a fight. It is reported to be looking for a London apartment to house executives who will need to be on call when the hostilities start. "It would be cheaper than hotel bills," says one Plessey manager, a veteran of the 1986 campaign. *–Peter Fletcher*

SEMICONDUCTORS

A NEW ROUND OF ISDN CHIPS

EINDHOVEN, THE NETHERLANDS

When a company that already makes more than 100 integrated circuits for telecommunication subscriber equipment announces with much fanfare that it is adding four more, as Philips International NV just did, there must be something special about the new ICs.

Indeed there is. For one thing, the four devices the Philips Components Division recently introduced in Zurich, Switzerland, considerably beef up the Philips product line of digital ICs compatible with integrated services digital networks: heretofore, the line had consisted of exactly one part, an echo canceler that was announced a year ago.

More important, the new ICs are aimed squarely at one of the last links in communication networks that have remained analog so far—the subscriber line and customer-premises equipment, including portable telephone sets.

The four parts underscore the importance Philips attaches to digital transmission technology. "Connecting a variety of customer-premises equipment to the digital communications network is now the single most important task for manufacturers of both telecom components and equipment," says Peter Draheim, director of the division's IC business unit. They also embody Philips's determination to cash in on a major trend in communications: the transition from wired to portable telephone sets, a trend reflected by the growing popularity of cellular radios, cordless telephones, and radio pagers.

The four entries include a microcontroller, a bus interface, a data-rate adapter, and a speech codec. The PCD3346 microcontroller is being billed as a first: it contains an on-chip electrically erasable programmable read-only memory that can be written and erased using the telephone-line voltage. As a result, the chip retains user-defined numbers without requiring battery backup. The second of the four is the PCB2310 integrated-services-terminal, or IST, bus interface. It allows equipment makers to build an ISDN-compatible local-area network that connects up to 32 voice and data terminals. Data can be exchanged on nine channels simultaneously over the IST-bus, with each channel handling a 64-Kbit/s transmission rate.

Philips wants to cash in on the transition from wired to portable telephone sets

Another new chip is the PCB2320 data-rate adapter. It adapts data terminals to 64-Kbit/s lines, thus helping to bring the benefits of ISDN to subscribers without requiring them to change their existing data terminals.

Finally, the PCB2322 speech codec is also designed for use on 64-Kbit/s links. Bringing ISDN's advantages to telephone sets, this circuit doubles the bandwidth of an analog telephone, thereby enhancing the speech quality. One or two of the ICs at each end of a phone link provide high-quality sound for a variety of equipment.

Philips plans to extend the ISDN product line still further, with more line-transmission terminators, terminal-adapter ICs, speech-coding devices, and IST-bus circuits. It will also introduce more derivative microcontrollers dedicated to telecom applications and continue to expand its range of ICs for cordless phones, pagers, modems, cellular and private mobile radios, and for conventional analog telephones.

The company has more than 60 engineers working on telecom product research. They have accumulated considerable expertise—the Philips ICs for telephone applications include about 50 MOS ICs, 40 bipolar ICs, and 15 application-specific microcontrollers. Among them are ICs for cordless and mobile telephones, modems, radio pagers, advanced feature phones and, naturally, simple analog-telephone sets. To control these devices, the company supplies microcontrollers with on-chip memories, repertory dialers, and connections to the Philips-developed industry-standard I^{2}C bus. Altogether, the telecom parts accounted for worldwide sales of more than $100 million last year, and Philips has ambitious plans to increase that revenue: Draheim says it's "a figure which we expect to double within the next four years." *– John Gosch*

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Telephone IC combines low-voltage operation and dynamic gain limiting

The TEA1064 is the highest performance speech/transmission telephone IC now on the market.

Working from line voltages as low as 1.7 V, the Philips TEA1064 telephone speech/transmission circuit with dialler interface incorporates dynamic gain limiting to reduce the distortion of transmitted signals and sidetone. Thus, no matter how loud the speaker's voice, the listener will always hear the message clearly. In addition, the IC supplies up to 3 mA for peripheral circuits.

The bipolar circuit performs all the speech and line interface functions needed in all-electronic telephone sets. The TEA1064 meets the performance requirements of all major international PTTs.

A range of options allows a manufacturer to base a whole range of telephones on this single IC. It provides single-ended or differential drive for a variety of earpieces. High-impedance inputs also suit the IC for all current types of microphones.

The IC's dynamic limiting output prevents distortion in the transmitted signal due to clipping. This allows the microphone input to be up to 13 dB higher than previous types for an output distortion level of just 2 percent.

The circuit produces an earpiece confidence tone during DTMF dialling, and a mute input disables speech during DTMF or pulse dialling. The DTMF amplifier is very stable, having a typical gain variation of ± 0.2 dB. Automatic gain control allows the circuit to connect to various exchange supply resistors and voltages.

In normal operation, the circuit works with line currents between 11 mA and 140 mA; with reduced performance it takes supply currents down to 2 mA at a line voltage of 1.7 V. The maximum continuous line voltage is 12 V. Operating ambient temparature range is −25 to +75 °C. The IC is available in a standard 20-lead plastic DIL, or an SO surface-mounting minipack.

CIRCLE 800

Two ICs working in first silicon complete MAC chip-set for DBS TV

The latest fruits of the cooperative effort between Philips Components, Plessey Semiconductors and Nordic VLSI to develop the first multi-standard MAC decoder chip-set are two ICs which complete the video/sound chain. These circuits - the MV1720 MAC control IC and the MV1730 MAC sound IC diffused by Plessey Semiconductors - are working to specification in first silicon.

Considering the size of the chips - 70000 transistors on 60 mm^2 for the MV1720 and 91000 transistors on 85 mm^2 for the MV1730 - the success of the first silicon is a tribute both to the Nordic VLSI design and to the diffusion process. The chip-set decodes all the MAC packet standards proposed by European broadcasters for satellite television.

The video/sound chain consists of the Philips MACAN (MAC ANalog) circuit TDA8734 and the MAC control IC MV1720, the MAC sound circuit MV1730 and the MAC video circuit MV1710 all diffused by Plessey. The chip-set is fully compatible with the Eurocrypt decrypting standard, which is now being submitted for approval to the E.B.U.

Philips Components and Plessey Semiconductors are planning to start production of the full chip-set in the first quarter of 1989 - in line with the launch dates of the major European TV broadcast satellites.

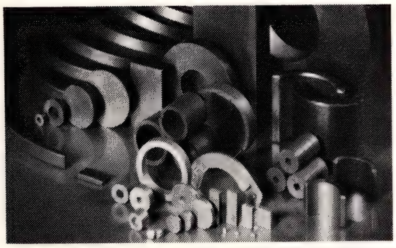
The successful operation of the chip-set was demonstrated in October by the Philips Components Application Laboratories in Mitcham (UK). The chip-set is compatible with CMAC, DMAC and D2MAC transmissions, suiting it for all the planned European DBS TV broadcast standards.

CIRCLE 801

CRTs □ PASSIVES □ SEMICONDUCTORS □ INTEGRATED

Philips Components

New ferrites and rare earths form permanent magnet range



Philips permanent magnets come in a wide variety of shapes and sizes.

Modern industry uses permanent magnets in a wide variety of products from computer disk drives to cars. Philips produces two groups of permanent magnet: hard ferrite and metal-alloy, also called rare earth.

The Philips hard ferrite line includes Ferroxdure (invented by Philips in 1952) which has now been developed to the fifth generation. The rare earth line includes Neodure, which is the strongest permanent magnetic material in the world.

The two main groups can be further sub-divided according to the manufacturing technology: sintering or plastic-bonding. Plastic-bonded magnets can be made in complicated shapes without additional cost but their magnetic performance is not as good as sintered magnets. The magnets can be made with isotropic or anisotropic properties.

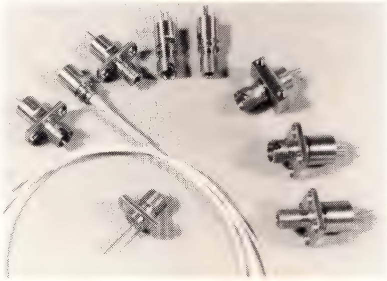
Ferroxdure magnets offer good magnetic properties at a low price and they are being used more and more in mass production. Plastic-bonded ferrites are an inexpensive solution in applications where complex shapes or unusual magnetization patterns are more important than magnetic strength.

Rare earth magnets are extemely powerful and are used where high magnetic strength and compactness are crucial, as in micromotors and magnetic switches.

CIRCLE 802

Low-cost laser receptacle connects to all fibre-optic connectors

Philips Components is launching a programme of laser and PIN diodes in a low-cost receptacle, which matches with all standard connectors currently used in the fibre-optic industry such as FC, SMA, STC, DIN, and pigtails. The receptacle is designed mainly for use in short haul optical communications systems such as LANs, ISDN and data links up to 2 km.



Our laser and PIN diodes are now available in this low-cost fibre-optic receptacle.

The receptacle accommodates all types of semiconductor laser. The company will offer its proven proprietary ranges of off-the-shelf lasers with wavelengths of 780 nm to 875 nm and 1300 nm in the receptacle. PIN-diodes matching the emitting parts in the receptacle are also available.

Various types of flange allow the OEM to adapt the receptacle to his own system design. In addition, it is suitable for either single-mode or multimode fibres. The receptacle benefits from automatic assembly techniques and the use of state-of-the-art laser welding techniques ensuring temperature stability, high precision, repeatability and high coupling efficiency.

CIRCLE 803

Cellular-radio RF power modules answer market demand

Responding to explosive demand in the new 900 MHz cellular-radio market, Philips is introducing two 6 W RF power modules which will ease the current restricted supply situation. The BGY91A and BGY91B are three-stage successors to the company's existing two-stage modules for 900 MHz cellular radio - the extra input stage cuts costs and design work for the setmaker.

The modules operate directly from motor-vehicle batteries, and differ only in their frequency ranges. The BGY91A, aimed at the U.S. market, operates between 806 MHz and 809 MHz; the BGY91B, aimed at the European market, operates between 870 MHz and 950 MHz.

The minimum output of 6 W at 30 mW drive power into a 50 Ω load ensures that ample power is available at the antenna. This prevents a cellular-radio set in transmission mode from over-driving a base-station, and possibly accidentally closing it down, if the vehicle gets too close.

The compact encapsulation, designated SOT233, measures just 30 by 17.6 by 9.6 mm.

CIRCLE 804

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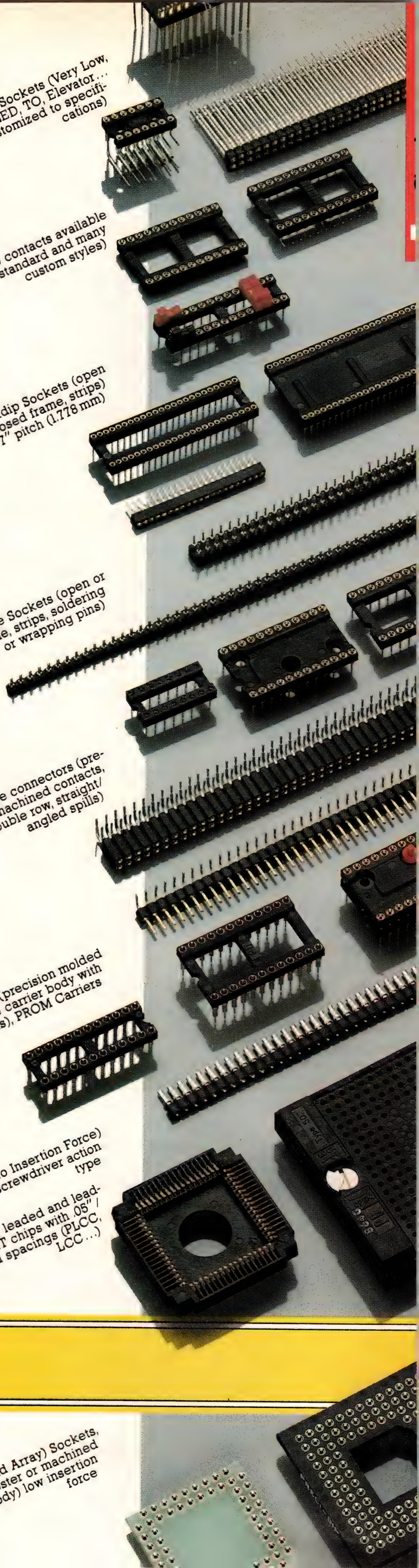

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HOW THE FAA AND NASA PLAN TO COMBAT WIND SHEAR

LEXINGTON, MASS.

Wind shear—the sudden change in wind speed and/or direction that can cause an aircraft to stall or drop rapidly, possibly crashing—is blamed for more than 500 deaths in almost 150 crashes in the past 15 years. It is especially dangerous if it strikes as a 150-mph microburst or a downdraft during takeoff or landing, when the flight crew has neither sufficient time nor altitude to react safely.

That's why the Federal Aviation Administration has stepped up its effort to develop equipment capable of detecting the phenomenon early enough to enable pilots to avoid it. It recently awarded a contract to Raytheon Co. for a ground-based airport radar system that alerts controllers to developing wind-shear conditions within 50 miles of the airport. And in concert with the National Aeronautics and Space Administration, the FAA is in the midst of a five-year program to develop airborne technologies to pinpoint hazardous weather. They include microwave radar, laser-based light-detection and ranging (lidar) systems, and infrared detection. The business potential for companies able to provide any of the systems ultimately chosen is huge. Prices could range from $50,000 to $100,000 per aircraft; thousands of planes will have to be instrumented.

Aircraft systems alone could be a huge market

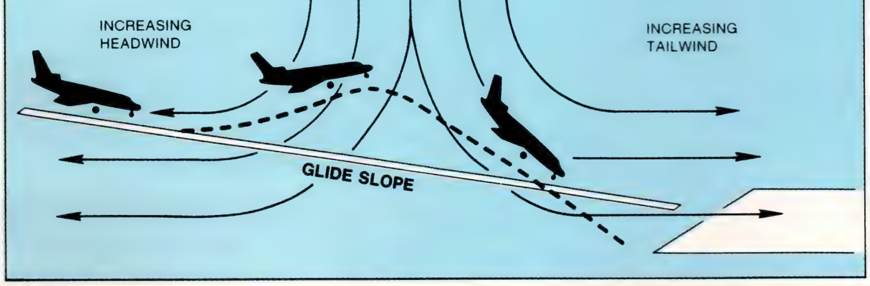
The award to Raytheon's Equipment Division in Sudbury, Mass., covers development and installation of 47 systems at airport terminals. The radars would provide ground controllers with a 5-to-10-minute warning if dangerous winds were approaching. Controllers would relay the warning to planes.

The multiyear contract includes an option for Raytheon to build 55 more systems to equip additional airports. The contract has a potential value of $282.5 million if all 102 of the systems are installed. The first radar will be delivered in late 1991 to the FAA's Technical Center in Atlantic City, N. J.

However, a warning from the ground-based terminal Doppler weather radar won't be enough to combat wind shear. The FAA has ruled that all commercial and commuter aircraft with 30 seats or more must be equipped with on-board systems by 1994.

The FAA seeks eventually to provide instantaneous on-board warning of dangerous wind shifts, rather than having the TDWR sightings relayed via ground controllers. The aim of the FAA-NASA effort is to provide the flight crew with an on-board alert in time to provide a 30-to-60-second window for evasive action.

For now, however, the ground-based radar "is the first line of defense," says Herb Schlickenmaier, project manager for airborne wind shear in the FAA's Flight Crew Systems Research Branch in Washington, D. C. For his part, Raytheon's Thomas McDonagh, manager of weather programs in the Equipment Division, says installation of the 102 TDWR



Wind shear, actually a sudden change in wind velocity, can cause an airplane to stall or drop. The FAA has awarded a contract to Raytheon for 47 systems to detect such changes.

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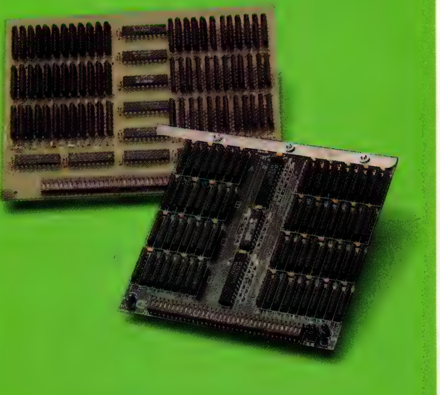

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systems "would cover between 80% and 90% of the flying public."

The 5.60-to-5.65-GHz C-band Doppler radars will transmit a narrow pencil beam to a range of 90 km, about 55 miles. The system can detect targets as small as raindrops, determining their velocity by measuring frequency shifts in the return signals. Raindrops blowing toward the antenna, for example, reflect a higher frequency than those that are moving away from it.

McDonagh says the return signals will be analyzed by a minisupercomputer operating in real time. It will be programmed to implement meteorological pattern-recognition algorithms developed by the Massachusetts Institute of Technology's Lincoln Laboratory in Bedford, Mass., that screen for hazardous winds.

Raytheon is designing the klystron-based radar transmitter, receiver, and signal processor for each radar system. The antenna and its pedestal, tower, and radome will be purchased, as will the minisupercomputer and two kinds of displays to be used by air-traffic controllers in the airport tower.

McDonagh says the FAA-mandated 5-to-10-minute warning that dangerous weather is approaching is "to enable aircraft to avoid the hazardous area. We'll be looking for gust fronts, which are slow-moving and not especially intense, but are precursors to violent microbursts. The goal is to identify the precursors before the microburst occurs." A microburst can strike the ground with a velocity as high as 160 mph, flattening large trees in much the same way that a tornado does, he says.

Tests last summer of a prototype Doppler radar at Denver's Stapleton Airport have encouraged the FAA. During the two-month evaluation, the MIT system detected 47 microbursts within five miles of the airport.

While Raytheon develops the radar, others are at work on the airborne forward-looking technologies that will follow it. Unlike ground-based radar, an airborne system could be tied directly into the flight director, an instrument that helps guide the aircraft. Using one of the on-board systems, the flight crew could immediately be apprised of an approaching microburst and directed on how best to avoid it.

GETTING CLOSE. "The technology is tantalizingly close," says the FAA's Schlickenmaier. By 1994, he says, "for the first time, we'll have a system on board that can give a time-critical alert." Of the three kinds of systems the FAA and NASA are studying, the X- and K-band radars work only in wet weather, lidar works best in dry weather, and infrared seeks out temperature variations in the atmosphere.

Radar is the most mature technology of the three. NASA is doing the microwave radar studies in house. NASA's Roland Bowles, technical director for wind-shear programs at Langley Research Center in Hampton, Va., says ground clutter is the main problem for radar, possibly causing signal returns to resemble hazardous weather patterns. But Bowles and Raytheon are both confident that ground clutter can be overcome with sophisticated signal processing and pattern-recognition algorithms.

Lidars aren't confused by ground clutter, but some contend that rain blacks out a lidar by attenuating the laser beam. Not so, says Russell Targ, senior staff scientist at Lockheed Missiles & Space Co.'s Research and Development Laboratory in Palo Alto, Calif. Targ says two kinds of lidars his company is developing have been able "to gather ample data to show that there's a hazard and help a pilot avoid that hazard from 4 km away." That's enough distance to provide a 40-

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second warning, Targ says. The lasers in the systems are either carbon dioxide at 10.6 mm or holmium YAG at 2.1 μm.

"We can sense and measure the strong winds right up to the core of a microburst," Targ says. "We can't penetrate the core, but our system will paint a picture of the microburst." Such a lidar system would carry a price of about $100,000 per aircraft, he estimates.

Donald R. Rogers, cofounder of Turbulence Prediction Systems of Boulder, Colo., says his company's infrared-based systems can detect the temperature differentials that occur during microbursts. "Microbursts are a cold-area event," he notes, "and we can pick up that cold area." Rogers says the IR system would sell for about $50,000. "The advantage of IR is that it works in both dry and wet microbursts," he says.

Neither the FAA's Schlickenmaier nor NASA's Bowles is backing one of the airborne technologies over the other. Both say the airlines and system builders will decide which is chosen. "Different airlines may opt for one or the other," Bowles says. "Not everyone will choose the same thing." *–Lawrence Curran and Tobias Naegele*

SOLID STATE

AT ISSCC, IDEAS ABOUND FOR BOOSTING THROUGHPUT

SAN JOSE, CALIF.

A rule of thumb: if you want to know what will happen in chip technology two to three years from now, check out the International Electron Devices Meeting each December. But if you want to know what's coming down the pike in the next few months, stop in at the International Solid State Circuits Conference each February.

If the rule holds true, it appears from a look at papers to be presented at this year's ISSCC that increasing system throughput is what's on the industry's collective mind. Conference goers who make their way to New York Feb. 15 through 17 will hear a slew of solutions: there are 64-bit-wide microprocessors and high-performance floating-point coprocessors, high-speed 512-Kbit and 1-Mbit static random-access memories, and sub-100-ns 16-Mbit dynamic RAMs. And the papers herald products that should be on their way to market in the next few months.

Conference will herald the move to 64-bit-wide microprocessors

Perhaps the most remarkable aspect of this year's conference is the shift it heralds to microprocessors with wider word and bus sizes. Even though many in the industry have been saying for years that such a move is unnecessary, the reason for its appeal now is obvious: more performance at lower cost.

By shifting to wider architectures and more efficient pipelining, designers can achieve higher performance without going to smaller, faster transistor structures. Another benefit of this architectural approach is that due to the wider bandwidth of the larger bus, the devices can employ slower and less expensive DRAMs. This obviates the need for such devices as fast SRAMs and specialized cache and first-in, first-out memories to eliminate the wait state often needed between main memory and the central processing unit.

In addition to the just announced efforts by Fujitsu Ltd. and the Europrocessor consortium [*Electronics,* December 1988, p. 29], several other moves in this direction will take the spotlight at the ISSCC. The most aggressive in its approach is Matsushita Electric Industry Co. of Osaka, Japan: its 1.2-μm CMOS implementation incorporates a full 64-bit reduced-instruction-set computer on the same 14.4-by-13.5-mm die as a 64-bit floating-point unit and a 1-Kbit instruction cache. Dissipating only 2 W, the Fujitsu microprocessor can perform a 64-bit add/multiply every 50 ns and a divide every 350 ns.

Taking a more cautious route to the 64-bit goal are three design efforts from Digital Equipment Corp. From its Hudson, Mass., center, DEC is showing a pipelined RISC CPU that incorporates a 1-Kbit instruction cache and a 2-Kbit data cache on-chip. Although it uses a 32-bit bus internally, the processor also incorporates a 64-bit-wide external data bus that can handle execution of instructions in a 20-ns clock period. The company estimates that the part's peak performance is 50 million instructions/s.

DEC's Hudson Center also will unveil a 32-bit complex-instruction-set CPU with a 2-Kbit instruction cache and on-chip memory management. In addition to a 32-bit address bus, the processor design also incorporates a 64-bit external data bus to boost performance, resulting in a cycle time of 28 ns.

On the West Coast, a DEC design effort in Palo Alto, Calif., has come up with a 20-mips implementation of a RISC design that uses relatively conservative 1.5-

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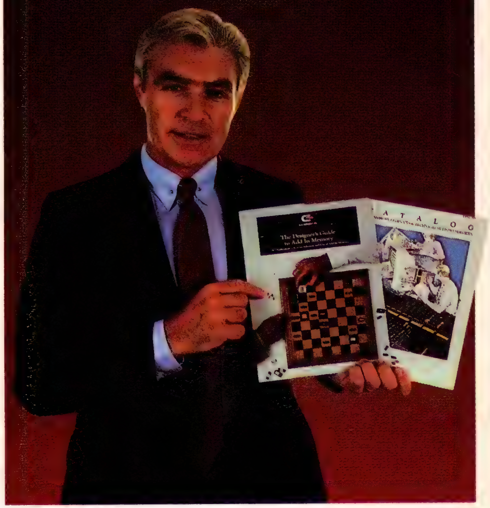
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μm design rules. It incorporates an internal 64-bit data bus to pipeline the 32-bit-wide instructions generated by the on-chip 32-bit ALU.

Aiming to keep up with the CPUs are a number of floating-point coprocessors. Going the 64-bit route is a design effort from General Electric Co. of Schenectady, N. Y. It's for a part containing an internal 54-bit array multiplier, a 64-bit-wide register—and, in addition to the 64-bit central processor, subprocessors for the calculation of mantissa and exponents. Using a 40-MHz clock, the processor is capable of 26.7 mips on double-precision, multiply/accumulate operations, one of the most time-consuming number-crunching jobs around.

Researchers from Mitsubishi Electric Corp. in Itami, Japan, have achieved 40 million floating-point operations/s using a 32-bit floating-point-processor design that employs 12 asynchronous pipeline states with self-timed data transfers. Still another approach is from DEC's Hudson facility, which has built a 50-MHz floating-point arithmetic unit containing five pipeline stages for concurrent instruction execution. This makes it possible to calculate single-precision results every 20 ns.

Going all out for precision and accuracy, researchers from NEC Corp. in Kawasaki, Japan, will describe an 80-bit floating-point processor capable of performing 22 math and 24 vector/matrix operations at a rate of 6.7 megaflops using a 20-MHz clock.

Addressing both the speed and density requirements of the new generation of microprocessors are SRAM and DRAM offerings.

In DRAMs, designers are still agressively pushing density to the 16-megabit level; but they are not forgetting about cycle time and the need to reduce the speed gap between the main memory and the processor. For example, Mitsubishi designers will describe a 3.3-V 16-Mbit circuit capable of access times as fast as 60 ns. It also includes a general-purpose register on board that allows transfer of data in as little as 15 ns.

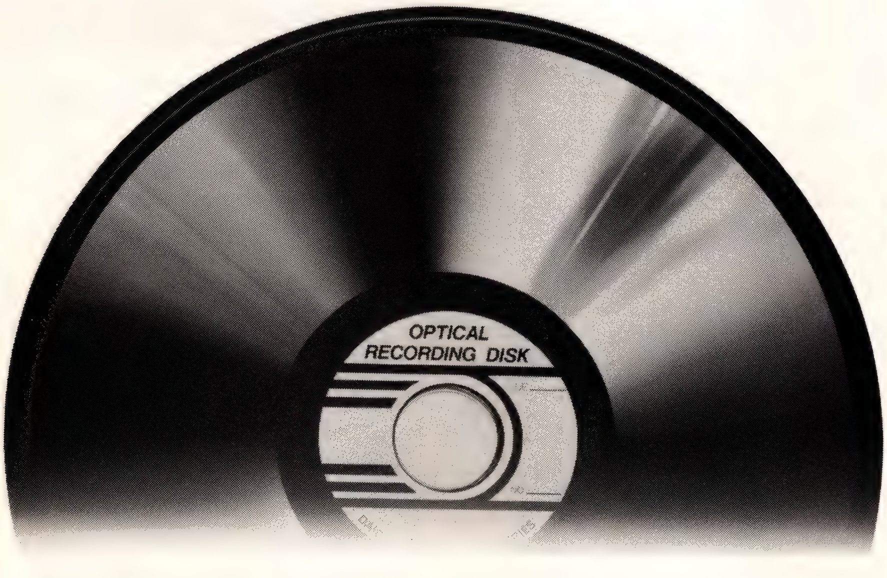
Sticking with five 5-V supplies, NEC engineers will report on a 16-Mbit DRAM design that boasts access times of 55 ns. The NEC device incorporates on-chip voltage conversion to get down to the necessary 3.3 V.

SPEED SPOTLIGHT. In SRAMs, meanwhile, researchers from Hitachi Ltd. in Tokyo have developed a 1-Mbit CMOS SRAM with a cycle time of only 9 ns, equal to or better than that achieved with some biCMOS SRAMs of lower density. Key to this design's combination of speed and density are the use of high-speed redundancy and a cross-coupled sense amplifier. The amplifier design features three-state p-channel MOS along with a triple polysilicon double-metal 0.5-μm CMOS process.

Reflecting the emphasis on overall system-performance improvement is a wide range of superfast analog offerings being shown at the ISSCC. In data converters, these include a 40-MHz, 8-bit CMOS subranging analog-to-digital converter with a pipelined, wideband sample-and-hold front end from Nippon Telegraph & Telephone Corp.'s LSI Laboratory in Atsugi, Japan. The part is fabricated in a 1-μm CMOS process. Matching it for speed and accuracy is a two-step a-d converter with a sample-and-hold comparator from Sony Corp. of Atsugi, Japan, fabricated with a more conservative 1.4-μm CMOS process.

Going for even higher accuracy and linearity is SGS-Thomson Microelectronics in Grenoble, France. At ISSCC, it will show a 13-bit CMOS a-d converter that operates at 160 KHz, using successive approximation and an untrimmed resistor string. *–Bernard C. Cole*

Daicel Chemical: A Worldclass Leader in Recording Materials



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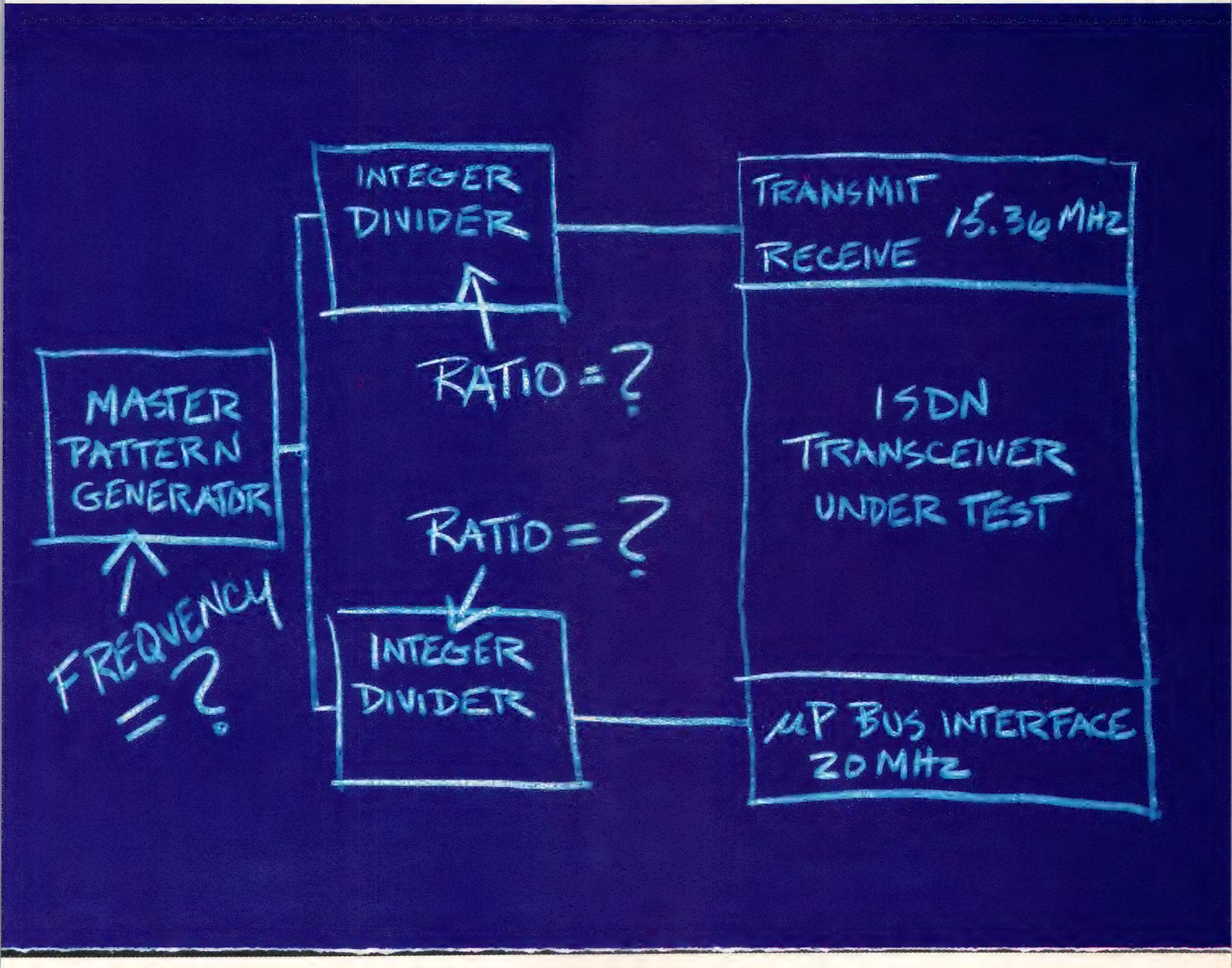
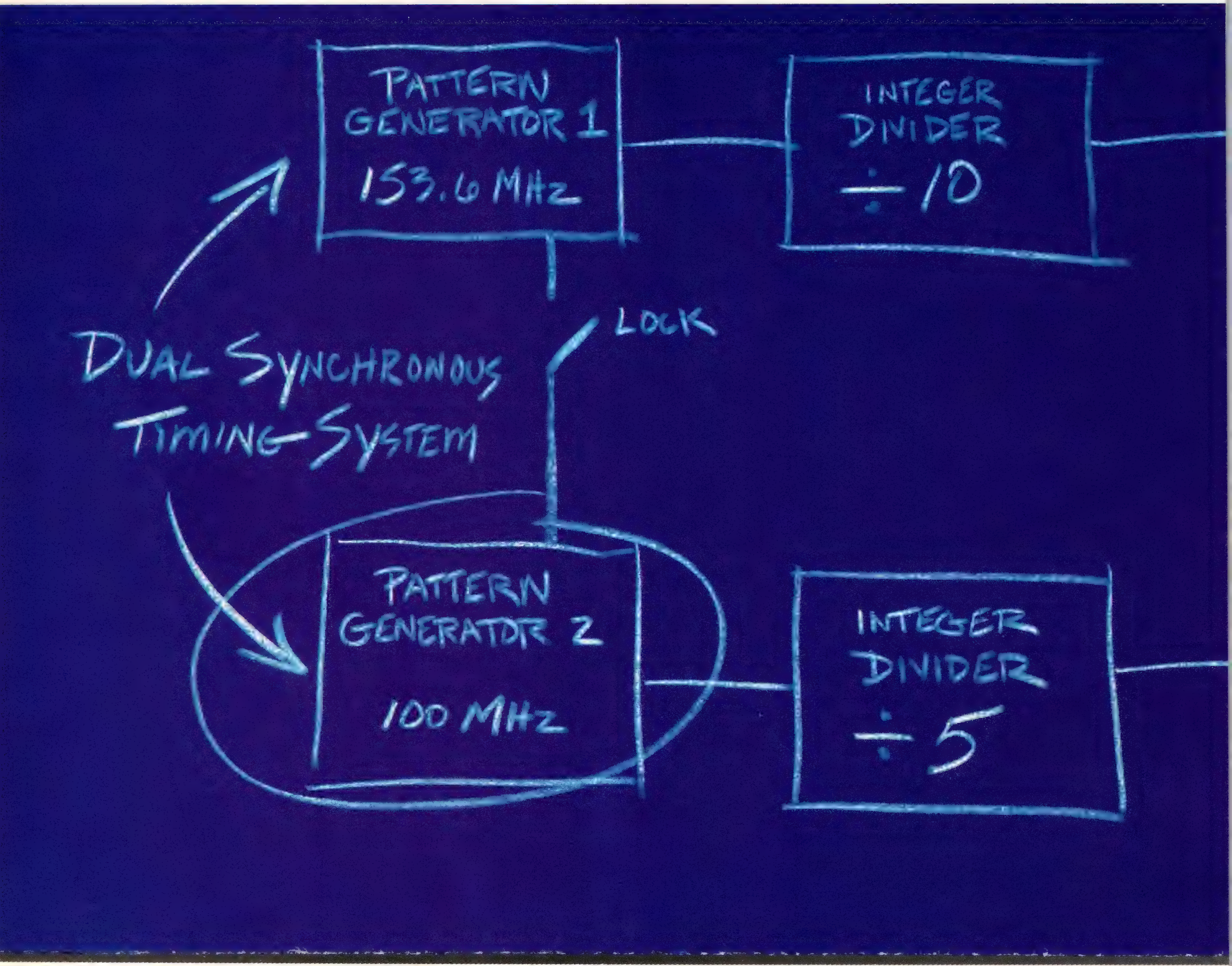
Can you solve this problem with a one-clock telecom tester?



This ISDN transceiver requires synchronized transmit/receive data at 15.36 MHz *and* a bus interface pattern at 20 MHz. Given the tester's single master clock, what frequency do you program? What integer ratios do the dividers need?

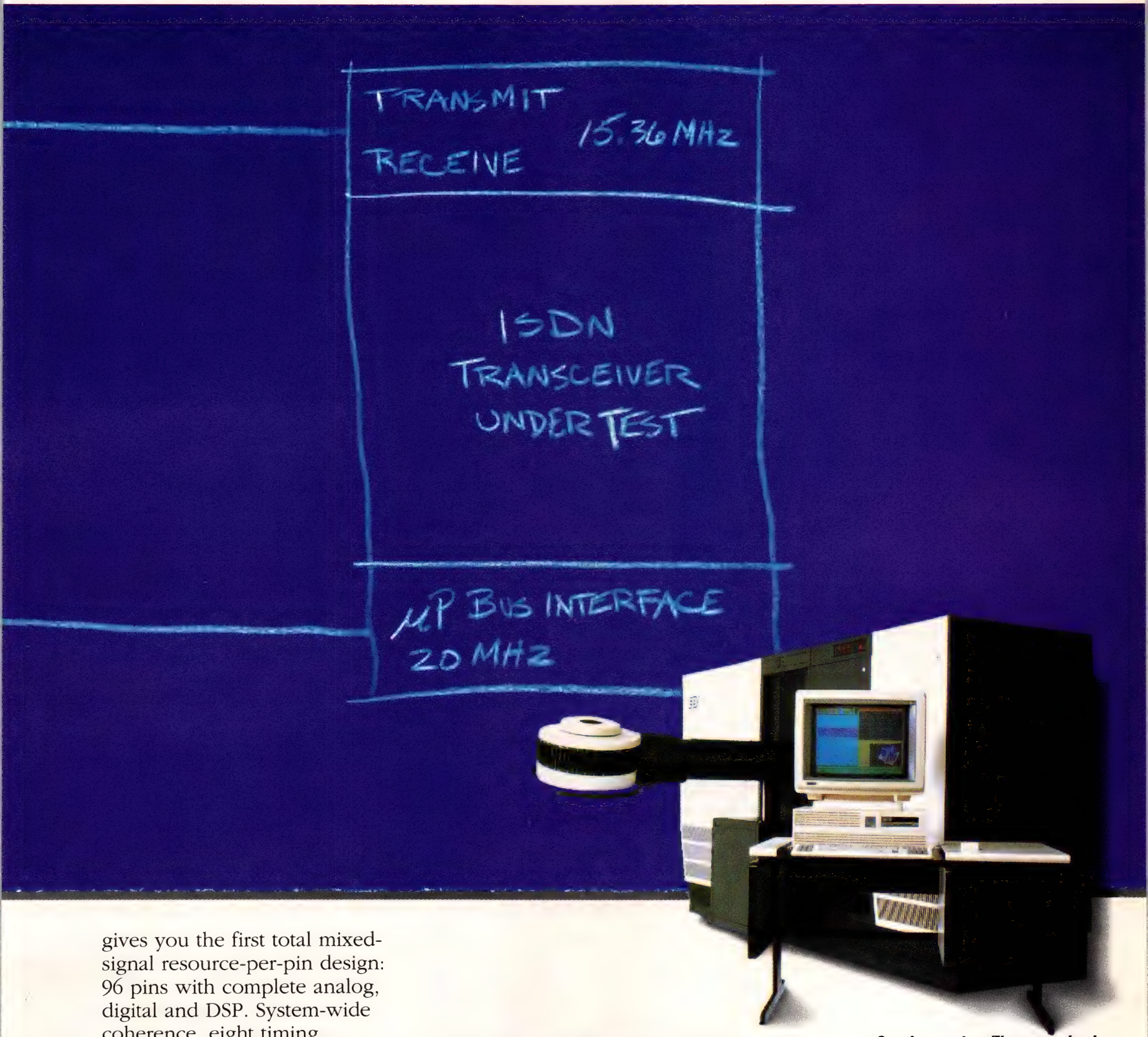


If you settle for anything less than Synchromaster, the new resource-per-pin mixed-signal test system from LTX, you're going to wind up one clock short. In order to produce test frequencies of 15.36 MHz and 20 MHz with a single-clock test system, you would have to choose integer ratios of 125 and 96 and set the pattern generator at 1.92 GHz — well beyond the typical 100-200 MHz range.

Only Synchromaster can produce the exact combination of frequencies this IC requires. Its Dual Synchronous timing system uses *two* high-resolution generators, so patterns and waveforms aren't constrained to just ratios of a single frequency, as they are in single-generator testers.

We've been through exercises like this many times, for many years. In fact, no one else comes close to LTX in mixed-signal testing experience. That's why the Dual Synchronous timing system is a design fundamental. And that's why Synchromaster

Need more time?
Get the tester with two clocks.



Synchromaster. The new mixed-signal tester from LTX.

gives you the first total mixed-signal resource-per-pin design: 96 pins with complete analog, digital and DSP. System-wide coherence, eight timing markers per pin, on-the-fly time set switching, and pattern rates up to 80 MHz. *And* techniques for solving the problems of jitter, pulse mask testing and other telecom measurements ... without compromise.

Send for our White Paper: "Telecom Testing Without Hangups," for the details on Synchromaster's Dual Synchronous timing system. Better yet, use the telephone. Call Carol Everett at (617) 461 1000.

It's why time has run out on one-clock testers.

LTX **Responds.**

Circle 39

HOW THEY'LL STEP UP TO 100-MBIT/S NETS

NEW YORK

Ever-increasing computing power now available for the desktop is forcing the companies that make chips implementing local-area networks to rethink both their technology and marketing strategies. The result is twofold: new chips are appearing that will speed up the LANs; and more emphasis is being put on cost-effective solutions for the customer's overall networking needs. Faster LANs are around the corner, but now, instead of connecting all users to the most powerful LAN—whether they need it or not—the cost-conscious concept is to hook up networks that use the same basic protocols but run at different speeds.

Not surprisingly, vendors of the three major network types—Arcnet, Ethernet, and token ring—all offer different solutions for combining relatively low-speed, cost-effective solutions with midrange networks of 10 to 20 Mbits/s. The strategies also include a migration path to even higher speeds, with the emerging Fiber-optic Distributed Data Interface a likely candidate to occupy the top of the LAN power pyramid.

Kicking off the new round of competition, Texas Instruments Inc. of Dallas last month announced 16-Mbit/s versions of its token ring to complement the present 4-Mbit/s implementations—and so did IBM Corp. [*Electronics*, December 1988, p. 23]. Meanwhile, Arcnet developer Datapoint Corp. of San Antonio, Texas, will try to leapfrog the field later this month by unveiling specifications for a 20-Mbit/s version of Arcnet: that's eight times faster than the present generation's 2.5 Mbits/s. Arcnet is looking for speed, building on its reputation as the least expensive LAN to install.

The Ethernet community, on the other hand, remains committed to its 10-Mbit/s standard. Rather than speed, Ethernet vendors are looking to drive down the cost per node by running an altered Ethernet on unshielded, twisted-pair telephone wiring instead of coaxial cable. Several companies are already marketing electronics gear for twisted-pair wiring, but the solutions are boards populated with discrete components. The standardization process for unshielded twisted-pair Ethernet is in the home stretch. By this time next year, VLSI solutions will be driving costs down toward $100 per node.

BIG GAINS. In the Arcnet camp, Datapoint says the 20-Mbit/s implementation will offer more than just an eightfold increase in the raw data rate. It will also deliver "significant gains in useful throughput, which will be proportionally greater than the increase in the data rate," says Michael Fischer, Arcnet's principal architect. Since not all the patents have been filed, the company will not disclose details nor projrct when chips will be available. But the large signal-to-noise ratio specified in the present-generation 2.5-Mbit/s Arcnet helped make the faster technology possible, says Fischer. The challenge of using multiple-transmission media has been solved, he says, and the 20-Mbit/s version will run on unshielded twisted-pair, coaxial, and fiber-optic cable. And, says Fischer, "it is our intention to have an LSI implementation; we're working with the Arcnet Trade Association on a standard."

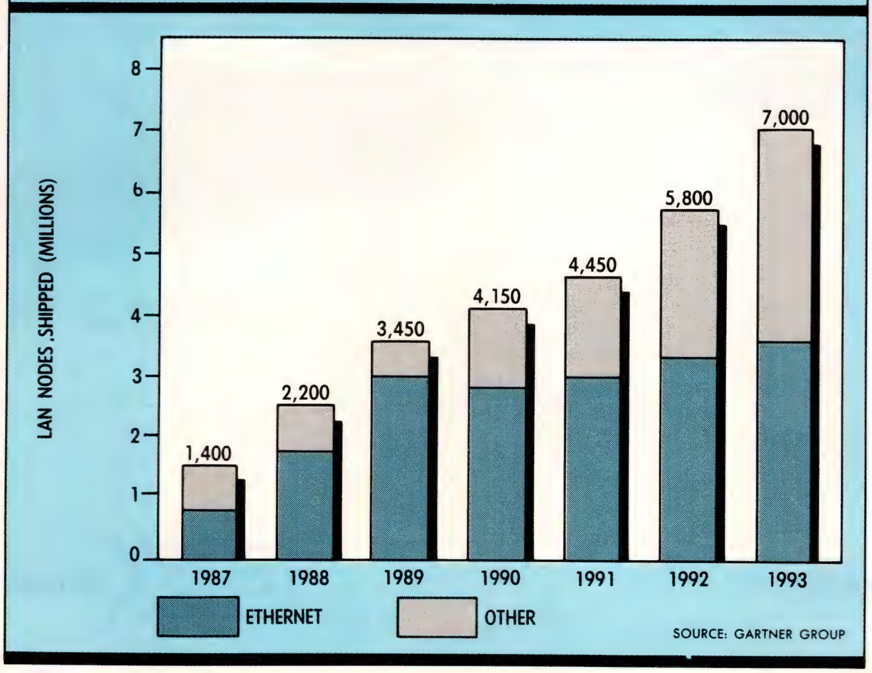
The task of integrating 2.5- and 20-Mbit/s versions of Arcnet is fairly easy, says Jim Christophersen, manager of product planning for Arcnet vendor Standard Microsystems Corp. of Hauppauge, N. Y. Since Arcnet uses a token-passing protocol and operates on a bus topology, both the 20- and 2.5-Mbit/s versions can coexist on the same cable. On the other hand, since competing networks based on a ring topology must run synchronously, they can handle multiple data transmission speeds only by using software bridges that reside in the LANs in file servers, he says. And this is likely to degrade overall throughput.

Because it can transmit data at 20 and 2.5 Mbits/s on the same cable, Arcnet's reputation for delivering a high percentage of its raw-data rate as useful throughput will be enhanced. First-generation Arcnet boasts throughputs comparable to Ethernet's 10 Mbits/s and token ring's 4 Mbits/s, says Fischer, and the 20-Mbit/s version will pull Arcnet well ahead. Its token-passing protocol eliminates the need to resend data because messages collide on the wire. Collisions are a fact of life with Ethernet's Carrier-Sense Multiple-Access/Collision Detection protocol, and the number tends to rise as the network load increases or the average packet size drops.

Arcnet has less data overhead—bits used to identify data packets, for example—than competing LANs, says Fischer. It requires nine bytes per packet, while token ring has 27 bytes and Ethernet has 72. This becomes less of an advantage if an application handles data in large packets. Arcnet's token-passing protocol allows it to implement its link-layer handshaking procedures on-chip and without the need for nodes to interact through software for confirmation. By contrast, Ethernet—because of the possibility of a collision—requires two acquisitions to the network and two transmissions. The token-ring protocol could implement link-layer handshakes without multiple acquisitions of the line, but the protocol that is actually used doesn't take advantage of this capability, says Fischer.

The 20-Mbit/s Arcnet will more than satisfy the needs of most users, says Christophersen of Standard Microsystems. While linking it to faster non-Arcnet LANs is feasible, the Arcnet bridge to 100-Mbit/s nets is far from the product

LAN GROWTH PICKS UP STEAM



SOURCE: GARTNER GROUP

TEXAS INSTRUMENTS REPORTS ON

GRAPHICS

IN THE ERA OF

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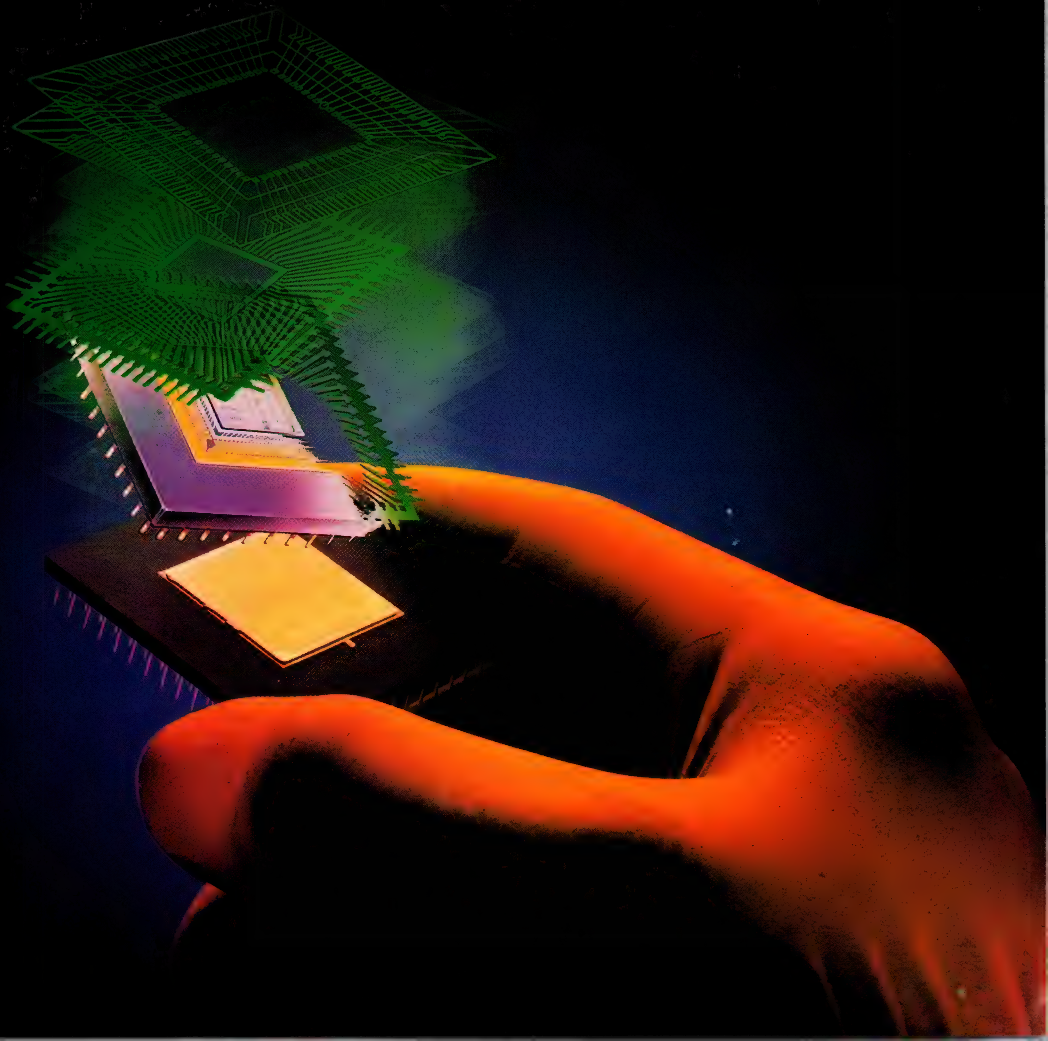

Graphics in the Era of MegaChip Technologies:

Why do industry leaders graphics processors from

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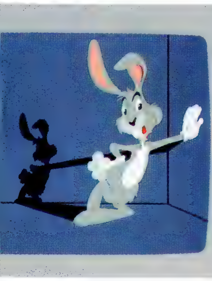
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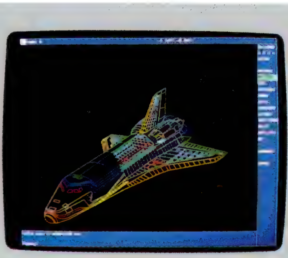
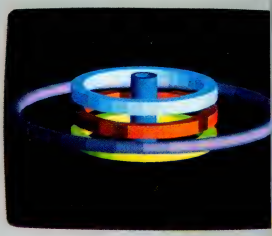

Matrox

National Design, Inc.


NEC Home Electronics

pick industry-leading Texas Instruments?

Stretching across the bottom of these pages is but a fraction of the hundreds of systems based on TI's industry-standard TMS340 graphics family. At the left is a Sun-3 utilizing TI's leadership '74ACT8800 building-block processor family. Which only goes to prove designers choose TI graphics products for everything from workstations to PCs, from laser printers to arcade games.

They get design options that allow them to differentiate their products and to better tailor price and performance to their markets.

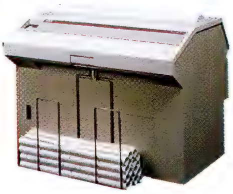
They also move to market faster with less risk. TI graphics products are proven, available, fully supported—the standard by which others are measured.

Let a few of the designers tell you about their choices:

"The TMS34010 was the only graphics processor that could meet the performance requirements of our laser plotter controller."

—*Al Sabel, Advanced Products Manager, Xerox Corporation*

The Xerox 8836 had to produce D- and E-sized drawings with a resolution of 400 dots per inch at a constant speed of one inch per second. The 34010 delivered: Six million instructions per second with a "draw" rate of up to 50 million pixels per second.



"The programmability and architecture of the TMS34010 provide the performance and flexibility we need for color- and graphics-intensive printer products."

—*Dr. Donald Parker, Exec. V.P. Products & Technology, QMS, Inc.*

Because the 34010 is programmable, QMS was able to build a printer that their customers could program to accept scanned color input and to provide high-speed color output as well as hard copy with multiple printer support.

"TI's ACT8800 technology allows our TAAC-1 application accelerator to significantly boost the computing power of a Sun workstation for imaging and graphics applications."

—*Nick England, Director Application Accelerator Group, Sun Microsystems, Graphics Products Division*

"The 8800's power lets us combine the functionality of an image processor, an interactive graphics device, and an array processor in a single product and still offer user programmability."

There's more in store from the ACT8800 family. The recently disclosed 8847 floating-point processor combines two 64-bit functions on a single chip: A floating-point multiplier and a floating-point arithmetic logic unit. Its number-crunching capability: 33 MFLOPS.

"In designing graphics systems, you can't forget about tomorrow. And TI hasn't."

—*Carl Calabria, Director of Engineering, Truevision® Inc.*

"The 34010 enables our TrueVista® video graphics boards to bring workstation performance to IBM® compatibles and Mac IIs. It is the only graphics chip that will allow us to migrate our applications software to even higher-performance second-generation TMS340-based systems." *See road map on next page.*

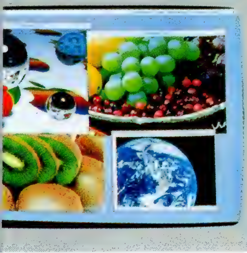
The TMS340 second-generation processor is upwardly object code compatible and three to 20 times faster than the 34010.

Two other products designed in parallel with the new TMS340 processor are the One-Megabit Video RAM and the industry-first floating-point graphics processor, with on-board, high-level graphics instructions.

The One-Megabit VRAM enhances the performance of the 34010. And when used in tandem with the second-generation processor, performance is improved up to 50 times over other processor/VRAM combinations.

The floating-point graphics processor executes up to 40 MFLOPS and interfaces directly with the address and data buses of the second-generation TMS340, allowing it to perform computation-intensive functions more than 10 times faster than current PCs.

For details on TI's software and third-party support, turn the page.

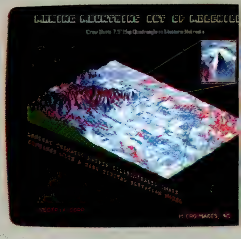


RasterOps

Renaissance GRX

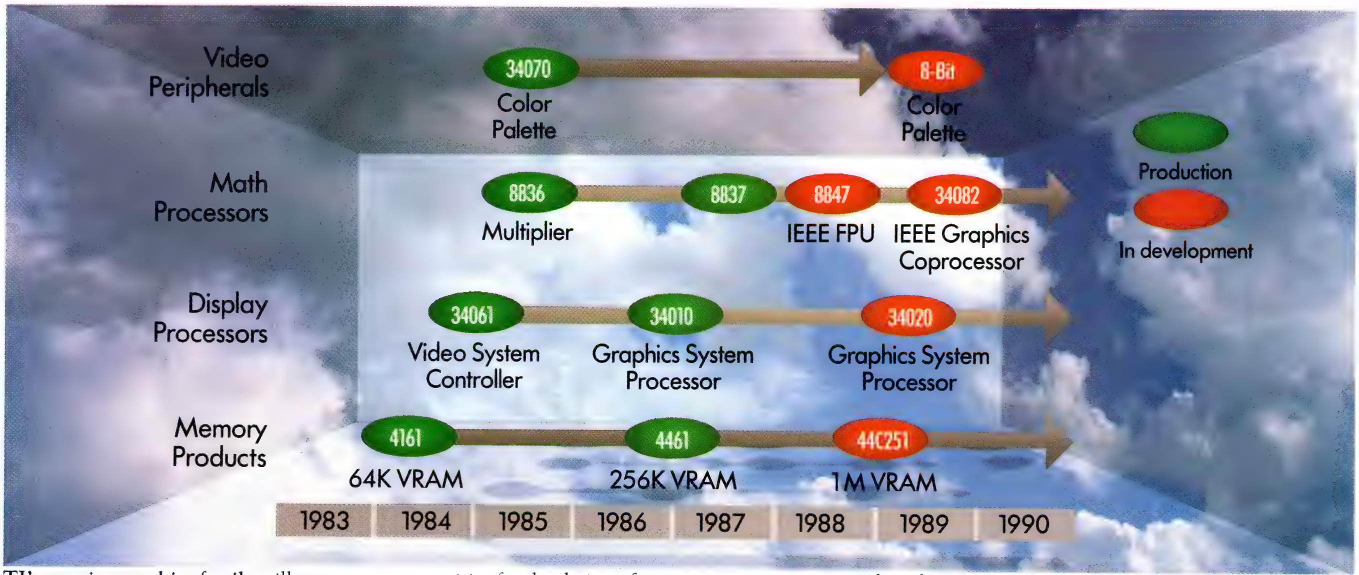
Truevision

Vermont Microsystems



Vectrix

Here's the road map to your graphics future ...



TI's growing graphics family will generate opportunities for the design of an even greater spectrum of graphics systems, matched much more precisely to the price and performance needs of the market. Selected TI graphics products are available processed to MIL-STD-883B. The 4161 64K VRAM is now available only in military versions, and a military-specified 34010 is on the way.

... and TI's comprehensive support will get you there.

Many designers find they complete their designs faster because of the extensive hardware and software supporting TI's graphics products. That for the new TMS340 family includes assemblers, linkers, simulators, compilers, software-development boards, and in-circuit emulators. New additions make this support even more helpful:

An 8514/A Emulation Library enables the TMS34010 processor to transparently emulate the 8514/A high-resolution color graphics add-in board developed by IBM for the Personal System/2™ line.

A CCITT Function Library allows the 34010 to operate as a high-performance embedded controller for image compression and decompression in fax applications.

A new paint program in the 34010 math/graphics function library provides everything necessary for drawing images on-screen.

Equally important, third-party support for the TMS340 family now tops 100 firms. Names and product descriptions are listed in TI's *TMS34010 Third Party Guide*.

ACT8800 evaluation and verification tools include functional and behavioral models and microcode-development software. An 8800 Software-Development Board and supporting software permit users to evaluate performance and write microcode for most ACT8800-family building blocks.

Join the many industry leaders who are using TI's graphics products in applications from plotters to games. An easy way to get started is to complete and return the coupon today. Or call 1-800-232-3200, ext. 3513.

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TEXAS INSTRUMENTS

stage. "Arcnet will be a participant in the next higher level of computer-to-work-station connectivity," he says.

Although a 20-Mbit/s Arcnet chip set is still on the drawing board, TI's two-chip set implementing a 16-Mbit/s version of the token ring is scheduled for delivery in March. TI's token ring is compatible with the IBM token-ring network specifications as well as the IEEE 802.5 and 802.2 standards. Besides quadrupling the first generation's 4-Mbit/s raw data rate, the 16-Mbit/s version offers full 32-bit addressing and up to 2 Mbytes of buffer memory, and allows a token-ring adapter to be implemented on a 10-in. card. Packet size jumps fourfold to 18,000 bytes, compared with Ethernet's 1,500 bytes and the 20-Mbit/s Arcnet's 4,000.

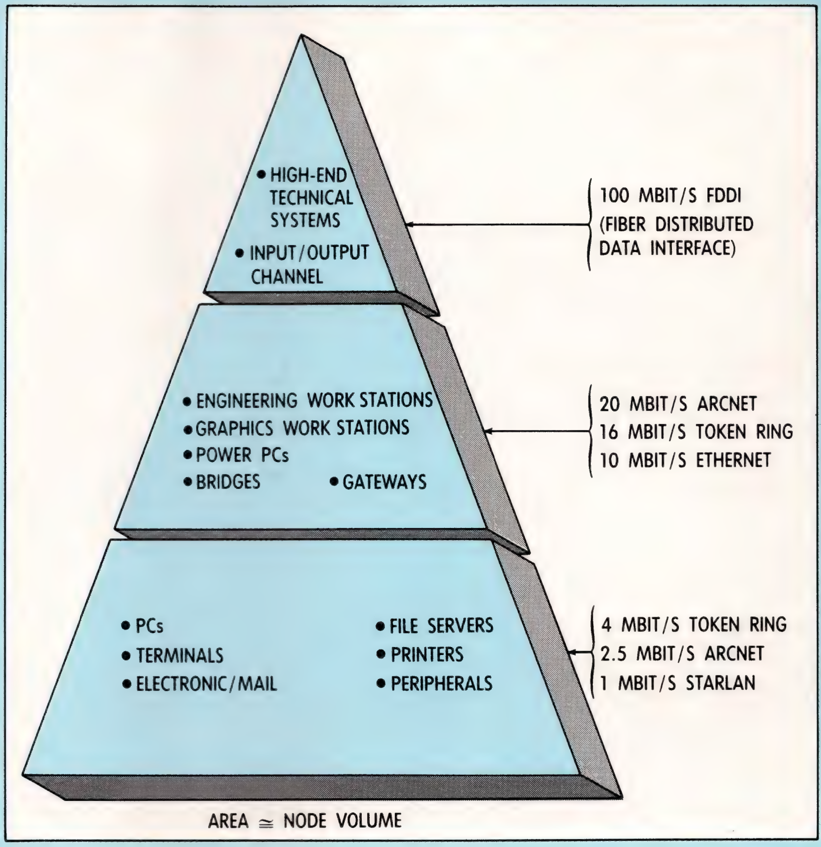
NO DELAY. To boost the ring's speed, TI teamed design and fabrication technologies, including high-speed, state-machine logic to assure that each node doesn't delay the network, says Leon Adams, the firm's LAN products marketing manager. The design is implemented in TI's 1-μm Epic CMOS technology for faster gate switching. The company also enhanced the interface to the transmission media, which can be either shielded twisted-pair wiring or fiber-optic cable. Running at 16 Mbits/s, a Manchester-encoded signal such as those used in the token ring requires a 32-MHz clock rate—and frequencies that cause high ring jitter, says Adams. New analog-to-digital-to-analog circuits fixed that problem.

Converting a token-ring network from 4 to 16 Mbits/s requires a new adapter card for personal computers hooked into the network, says Adams. But since the original token-ring architecture was designed for 16 Mbits/s, network equipment need not be replaced.

Just as the 20-Mbit/s Arcnet is expected to boost useful data throughput, so the faster token ring will offer increases proportionally greater than the increase in the raw data rate. Three factors boost data throughput, says Adams: the raw data rate; the increased packet size; and a high-speed direct-memory-access interface with the computer-system bus. The fourfold increase in frame size to 18,000 bytes is a natural result of the speed increase, but has the added advantage of reducing transmission overhead. In a token-passing network, packet size is limited by a timed period in which the node has an opportunity to hold the token, and the 16-Mbit/s version can transfer four times the information of the 4-Mbit/s version in the same time interval, he says.

The biggest advantage of larger packets, says Adams, is the time saved in preparing packets for transmission. Smaller transmission packets mean a large block of data has to be diced up at the sending end and then reconstructed at the receiving end—all of which takes time, he says.

NETWORKING'S POWER PYRAMID



> Sometime next year, VLSI solutions will cut Ethernet costs to $100 per node

TI projects three applications for the 16-Mbit/s token ring: as the primary LAN for work stations and other high-end processors; as a high-speed backbone network bridging 4-Mbit/s LANs; and to support communications gateways to higher-speed networks such as FDDI.

Of the three major network architectures, only Ethernet is standing pat on its first-generation data rate. Its 10-Mbit/s raw speed role in helping Ethernet carve out a 50% market share. It is expected to remain dominant through 1993, says the Gartner Group Inc. of Stamford Conn.

Instead of trying to boost speed, the Ethernet community is working on bringing down cost per node, which at about $1,000 is now some five times Arcnet's cost and roughly equal to that of the token ring. Since the transmission medium represents a major investment, vendor efforts have focused on hammering out a standard for running Ethernet on the phone company's unshielded, twisted-pair wiring. The work is being handled by the 10 Base-T Committee of the IEEE 802.3 Committee for Ethernet standards.

Twisted-pair Ethernet, however, works largely because it differs from the traditional coaxial-cable versions in two ways. It implements a star instead of a bus topology, and its maximum point-to-point run length is 100 meters vs. 500 meters for an entire Ethernet bus, says Pat Thaler, principal engineer at Hewlett-Packard Co.'s Networks Division in Roseville, Calif., and head of the 10 Base-T group.

NO CONFLICT. Since the star topology connections are point-to-point, says Thaler, multiple signals do not have to contend with each other on the line. Transmission is further simplified by using one wire of the pair to send and the other to transmit. Right now, the adapter boards, medium-access units, and hubs provided by a number of vendors do not offer significant cost advantage compared with coaxial-cable Ethernet, because "they have a lot of magnetics, resistors, and capacitors. All the solutions are presently discrete," says Richard Brand, manager of network product marketing at National Semiconductor Corp., Santa Clara, Calif.

The solution is to integrate functions into a chip set, driving the costs per node to around $100. National expects to do exactly that once the standards are set by the 10 Base-T Committee sometime within the next four months. *–Jack Shandle*

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Circle 46

JANUARY 1989

WASHINGTON INSIDER

WITH ITS VHSIC WORK COMPLETE, IBM FACES A MARKETING NIGHTMARE

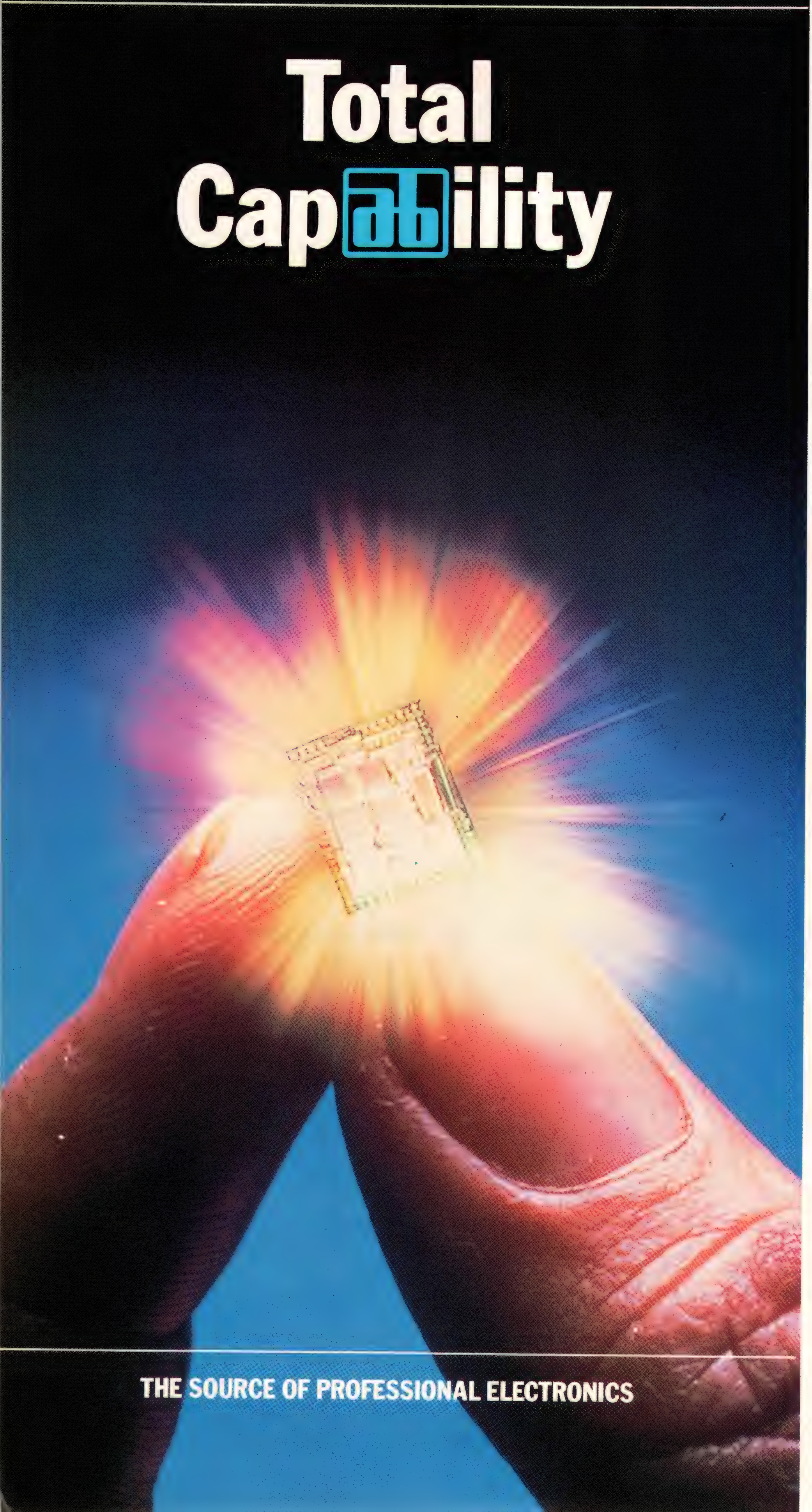
After finishing its work in the second phase of the Pentagon's Very High Speed Integrated Circuits program, IBM Corp. is stepping up its efforts to market the technology. It won't be easy. IBM concluded its three-year VHSIC contract by demonstrating a prototype of an acoustical beam former, made entirely of 0.5-μm VHSIC parts, to Defense Department officials in December. But the system, designed for use in BSY-2, the submarine electronics package for the Navy's next-generation Sea Wolff attack sub, will probably never be used. IBM lost the BSY-2 program to General Electric Corp. last year [*Electronics,* Feb. 18, 1988, p. 107]. "We've bid into a lot of programs unsuccessfully," says an IBM official, close to its VHSIC effort who blames an intransigent military bureaucracy for failing to see the advantages of the new technology. "VHSIC was supposed to get military semiconductor technology to the edge of the state of the art. It did. But they haven't been able to deploy it." IBM isn't giving up. "We'll sell boards, we'll sell chips, we'll sell design services, and we'll act as a foundry," says Philip B. Johnson, a manager in IBM's VHSIC program office in Manassas, Va. "We're committed to making this work." ☐

NOW THERE'S A CHEAPER WAY TO SHIELD SENSITIVE COMPUTER ROOMS

Defense contractors who need highly secure, shielded computer rooms now have a less expensive, more flexible alternative. USG Corp., a Chicago building-products manufacturer, has developed a line of shielded-room systems, called Instar, that relies on an interlocking-seam system permitting lighter-weight panels and requiring no welds or bolts. Instar shielding meets federal requirements for containing radio-frequency and electromagnetic emissions between 1 KHz and 10 GHz, USG says. Yet it costs only \$18 to \$26/ft^2 well below the \$32 to \$55/ft^2 that conventional shields go for. And unlike conventional heavy steel or steel-lined panels that must be bolted or welded together, Instar rooms can be easily disassembled and moved. To make it easier to put a room together, USG is planning to introduce a computer-aided-design software package for room designers at next month's Armed Forces Communications and Electronics Association show in Anaheim, Calif. ☐

HIGH-DEFINITION TV IS HIGH ON THE AGENDA FOR A KEY HOUSE SUBCOMMITTEE

The House Subcommittee on Telecommunications and Finance is giving high-definition TV a prominent spot on its agenda for the coming legislative session, and some Congressional action on the technology is likely before summer. Subcommittee chairman Rep. Edward J. Markey (D-Mass.) has given industry groups until Feb. 1 to file "action memos" on how government and industry might work together to jump-start the moribund U. S. consumer electronics industry. Hearings will then be scheduled to discuss the issue further. One committee member already has his mind made up, though. "Being involved with HDTV is at least as important to the U. S. government as Sematech," says Rep. Donald Ritter (R-Pa.), referring to the government-industry semiconductor manufacturing consortium, which is costing U. S. taxpayers \$100 million a year through 1992. Just how government and industry will get together on HDTV, though, has yet to be sorted out. The idea of a consortium, perhaps partially financed through the National Institute of Standards and Technology—the newly renamed National Bureau of Standards—has gotten the most attention. In any case, Ritter predicts strong support from the executive branch: he says John Sununu, the new White House chief of staff, is "inclined toward science and technology issues." And he says action must be taken soon. "The technological and economic impact of HDTV will be enormous. We can't sit around and jawbone this thing to death." ☐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Circle 47

PACIFIC RIM TRENDS

A NEW STANDARD TAKES FAX A STEP UP IN QUALITY AND SPEED

A new era in facsimile—with faster, sharper, multiple-access transmission—is about to get under way in Japan with the introduction of standardized Group-4 machines from major Japanese manufacturers. The final obstacle, proof of compatibility among prototype G4 machines from 13 manufacturers, has been passed. The victory came in a test using Nippon Telegraph & Telephone Corp.'s integrated services digital network, INS Net64, which started in April 1988 and is now used by more than 100 companies in 27 major cities in Japan. G4 facsimile will provide users with better performance that includes high-speed transmission, multiple-access capability, high-capacity memory, laser printing, and a super-fine transmission mode. Transmission time and cost will be only one sixth that of today's G3 resolution. A multiple-access function means that the G4 can communicate with the current G3 machines. G4 fax resolution—16 by 16 dots/mm— is eight times that of the G3 standard mode. Industry insiders estimate 19,000 G4 machines will be shipped in the Japanese market in fiscal 1989, and that the figure will grow to 72,000 in fiscal 1991. Initial prices in Japan are not low; one model from Matsushita Graphic Communication Systems Inc., Tokyo, goes for about $25,000. □

TOP SUPPLIER MEETS BEST-SELLER: FUJITSU ADAPTS ASIC DESIGN TOOLS TO SUN

The world's top supplier of application-specific integrated circuits, Fujitsu Ltd., isn't about to rest on its laurels. Aiming at further growth, it is recompiling its ASIC design software to run on Sun Microsystems Inc.'s engineering work stations. The recompiled programs will be available in January, starting with Viewcad large-scale logic simulation and data-transfer functions. The Zephcad and logic-input and rule-checking of Viewcad are scheduled to be shipped in April at the earliest. Fujitsu expects that recompiling tools for Sun's electronic work stations will strengthen its position in the ASIC market not only in Japan but in the U.S. Around 1,000 copies of Viewcad and Zephcad are now being used by 135 companies in the domestic market. □

MITSUBISHI TO BRING TOKEN-RING NETS TO JAPAN PC USERS

Japan's best-selling personal computer, NEC Corp.'s PC-9801 series, will soon be able to talk to IBM computers in the same local-area network. The marriage will take place next month when Mitsubishi Corp. of Tokyo starts marketing token-ring-related products from England's Madge Networks Ltd. Mitsubishi expects the initial annual sales of the Madge Network products to be $1.2 million. The new products will be imported by Mitsubishi and sold by Advanced Systems Technology Inc. of Tokyo. □

EIAJ IS BEARISH ON INDUSTRIAL EQUIPMENT PRODUCTION

More industrial electronics equipment is being produced outside Japan and the trend is growing rapidly. That's the conclusion the Electronic Industries Association of Japan draws from its five-year forecast of the prospects for the industrial-electronics equipment business. The prediction is that production will grow at an average annual rate of 9.9%, considerably lower than the 14.9% rate chalked up for the past five years, according to the forecast. In the same pessimistic vein, the consensus view in the *Electronics* annual market forecast (see p. 110) puts 1989 growth for the equipment market at 5%. The EIAJ predicts that output in fiscal 1992 will amount to $114.3 billion, a 60% increase from fiscal 1987. Computers and computer peripheral equipment output, which account for more than half the total, are expected to increase at an average annual rate of 13% during the next five years to $66.8 billion in fiscal 1992. □

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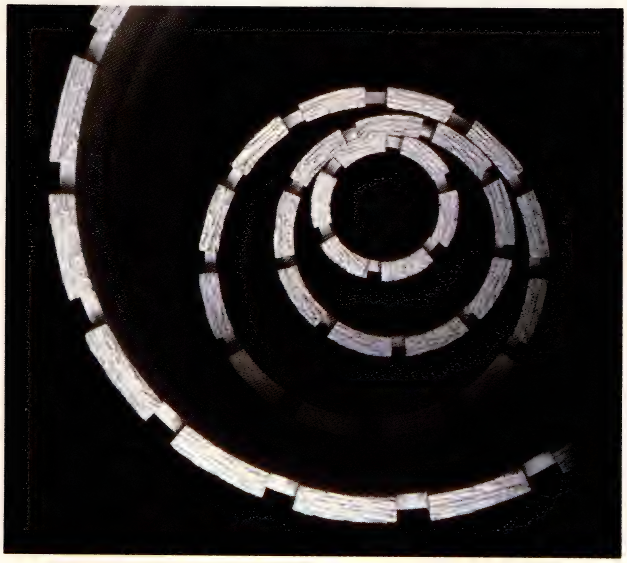

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Circle 50

EUROPEAN OBSERVER

EUREKA LAUNCHES A MAJOR COOPERATIVE SOFTWARE EFFORT...

Thirteen European firms from five countries—France, Norway, Sweden, the UK, and West Germany—are joining in a Eureka project to boost the continent's know-how in software and strengthen its competitive stance on the world's software markets. Participants in the new Eureka Software Factory (ESF) aim to improve software-development productivity, work out European standards, and develop a software library. The 10-year effort, which the individual governments and participating firms will support to the tune of $420 million, is being masterminded from ESF headquarters in West Berlin. Raising productivity is a pressing problem since demand is beginning to outstrip development capacities, the ESF says. In Western Europe, the software market is growing about 16% a year and should reach $45 billion in 1992. Eureka, the European Strategic Program for Research and Development in Information Technology, is a pan-European initiative. Among ESF participants are France's Matra, Norway's Norsk Data, Sweden's Telelogic, the UK's ICL, and West Germany's AEG, Softlab, and Nixdorf Computer. □

...AND A PROJECT THAT TARGETS NEURAL NETWORKS FOR FACTORY USE

Boosting the industrial use of neural networks is the focus of a brand-new joint European Esprit project, the Application of Neural Networks for the Industry in Europe. Participating in Annie are 10 firms and research organizations in four countries. The $6 million project aims to help Europe maintain its relatively strong position in neural-net research vis-a-vis the U. S.—the American lead is fairly small. It aims to develop software tools and to demonstrate the superior performance of neural nets. Heading the project is Harwell Laboratory, the UK Atomic Energy Authority's main lab. Among the participants are West Germany's Siemens AG and the Technical University of Darmstadt; the UK's British Aerospace and Artificial Intelligence; the French mechanical R&D center, Cetim; and two Greek firms noted for neural-net research, Alpha and NTU. □

THE UK'S STC IS SET TO BUY U. S.-BASED SUPERMINI MAKER

Look for a happy corporate wedding between STC plc, the big British telecommunications and computer combine, and Computer Consoles Inc., the U. S. maker of superminicomputers and associated Unix-based software. STC wants to buy control of the Waltham, Mass., company for $168 million, and Computer Consoles' management is agreeable. The two firms have long been linked: STC is UK sales agent for Computer Consoles' line of phone-company directory-assistance systems, and ICL Ltd., an STC unit, puts its own label on a range of Computer Consoles' superminis, the DRS Series 500. ICL has also taken on the Computer Consoles proprietary networked office-automation software, Office Power. Computer Consoles also will be coming out with a new line of superminis called the Power 7 series, which features custom reduced-instruction-set processor chips and the Unix-compatible, fault-tolerant, operating-system software Perdos. □

AEG AND INTEL WILL JOINTLY DEVELOP 1.5-MICRON ASICs

Telefunken electronic, the West German chip-producing arm of AEG AG, will jointly develop application-specific integrated circuits with Intel Corp. of Santa Clara, Calif. Since AEG is part of the aerospace and motor vehicle group Daimler-Benz AG, observers speculate that the ASICs will primarily be for in-house use, in Mercedes cars and trucks and in the avionics systems that Daimler makes. Telefunken of Heilbronn will design the ASICs and Intel will produce them, using its 1.5-μm CHMOS process. □

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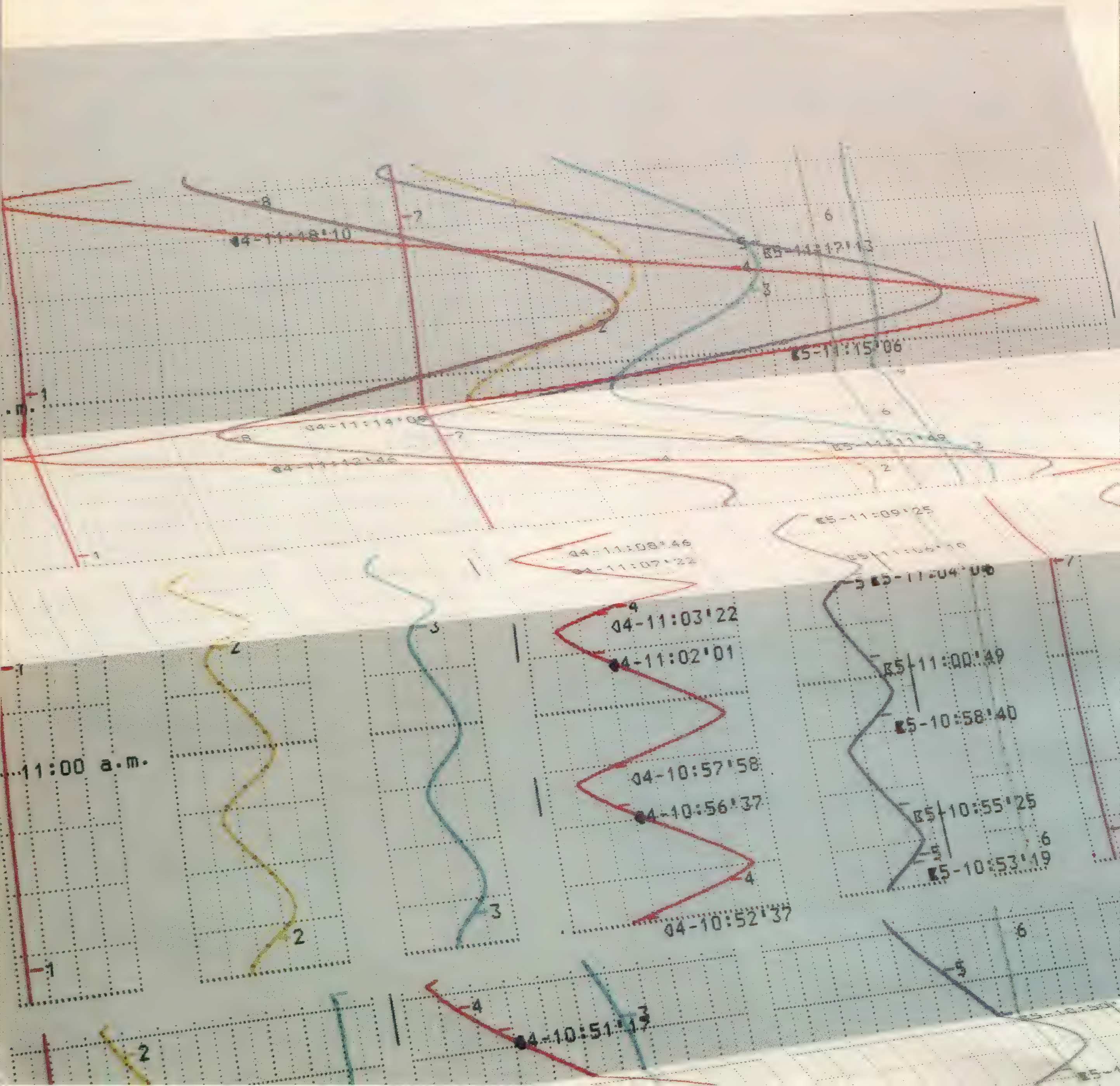

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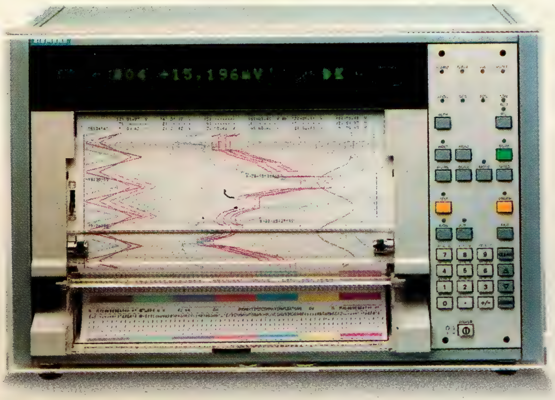

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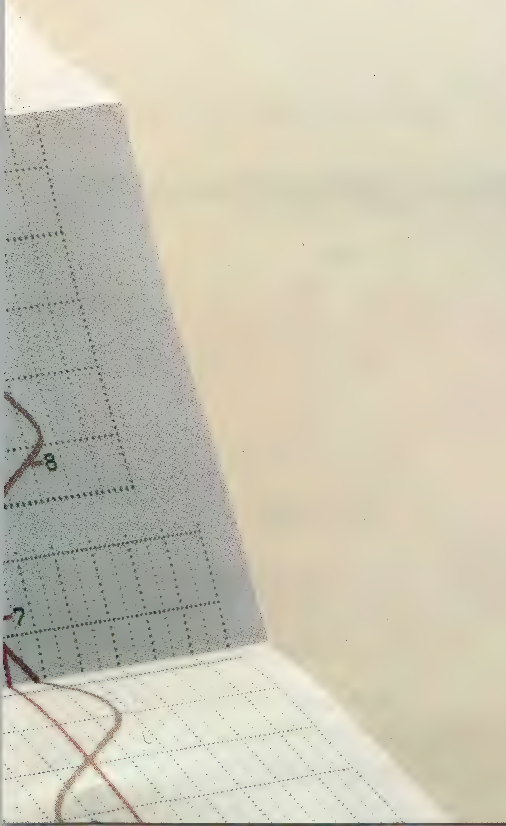

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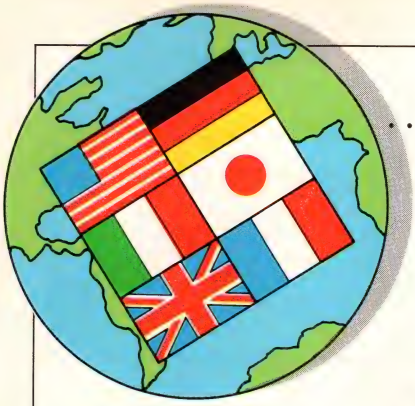


1989 U.S. AND OVERSEAS

LOOKING FOR A SOFT LANDING AFTER HYPERGROWTH

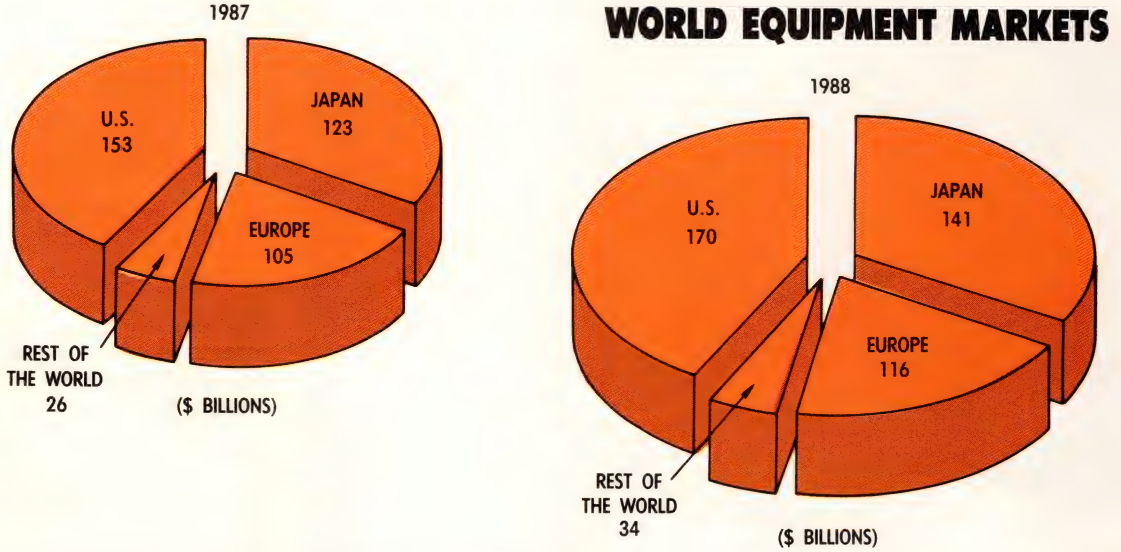
The world electronics industry, flying high for most of 1988, ran into some turbulence in the fourth quarter, and its markets are now set on a long glide path: slow but steady drops in growth rates as 1989 progresses. Although nearly all major industry segments are being buffeted by a gathering storm of uncertainty, modest growth—instead of a big plunge in sales—will nudge world electronics consumption over the half-trillion dollar mark for the first time in 1989.

According to the annual Electronics *market forecast survey, worldwide consumption of electronic equipment will grow only 10% in the coming year to $505 billion. In contrast, the industry saw equipment consumption reach $461 billion in 1988, a gain of 13% over the previous year's $407 billion.*

The U. S. will remain the world's largest equipment consumer at $185 billion in 1989, but the market's slowdown in growth will be even more marked—only an 8.8% increase overall after the ebullience of an 11.1% accrual last year. The four big European markets (West Germany, UK, France, and Italy) will also see the growth rates skid in 1989, slowing from 10% last year to 8%. And the Japanese appetite for electronic goods will moderate next year as well, falling from 14.7% to 12.2%.

A number of factors are contributing to the global slowdown in equipment orders. A

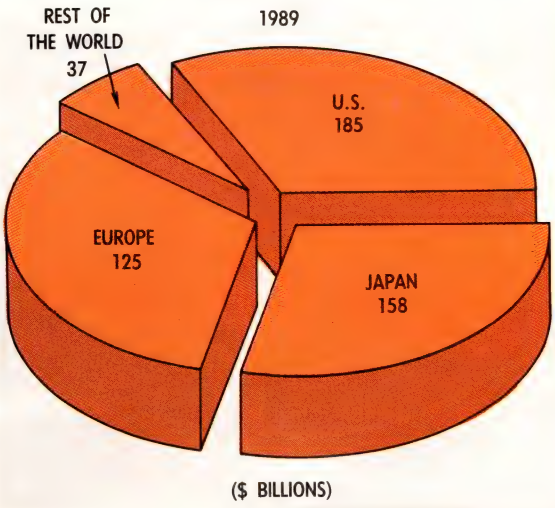
WORLD EQUIPMENT MARKETS

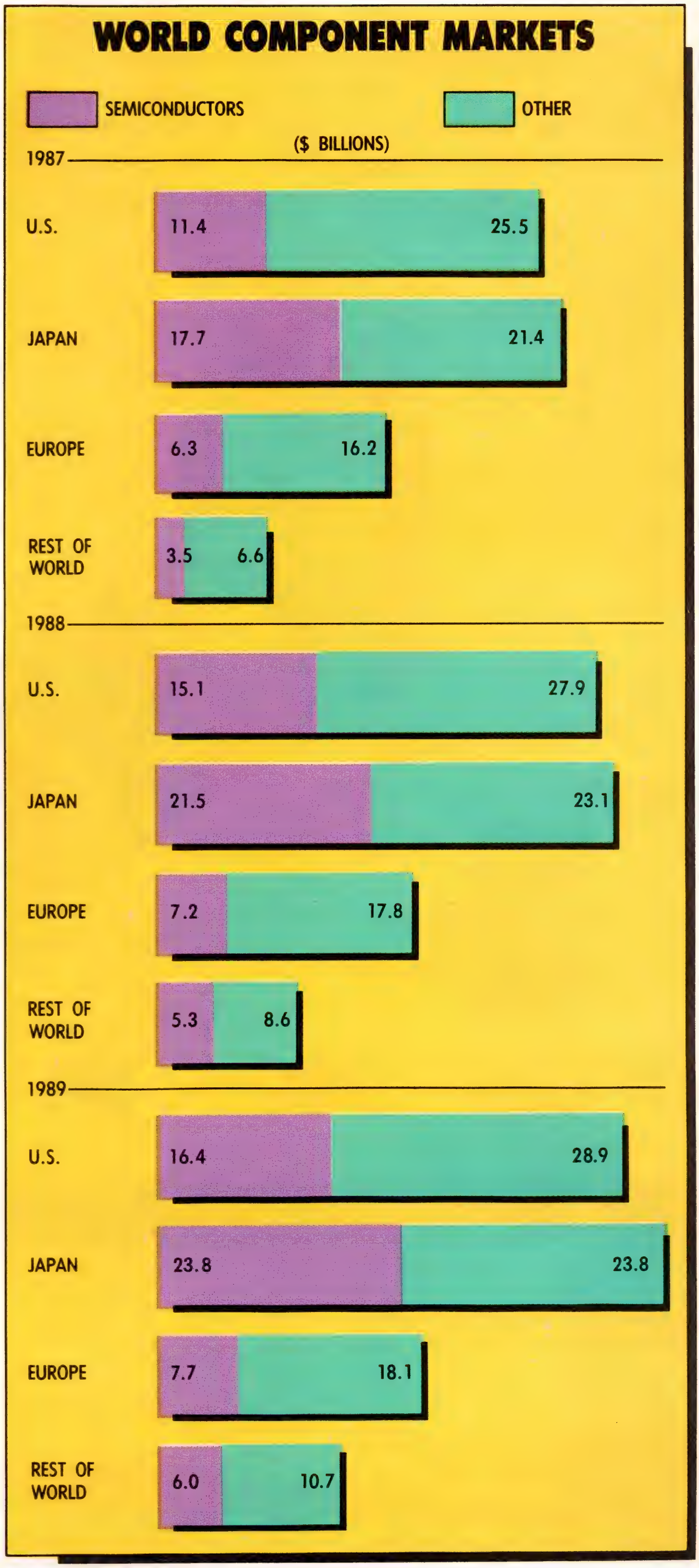


major influence is the U. S. economy. A decided slackening of the overall economic growth rate, down to between 2% and 2.5%, is in store, many economists say. In fact, signs of a slowdown began to appear late last year in the wake of what had been healthy 3.5% growth. Also, the huge U. S. federal deficit continues to worry both U. S. and foreign business interests. If the incoming administration is unable to deal with the country's debt effectively, the U. S. economy could be in for further strains.

Inflationary trends are beginning to be perceived; and interest rates are on the rise, which could put a brake on business expenditures for computers and other big-ticket electronic systems. In fact, the worldwide computer industry's softening in the last quarter, particularly in the personal-computer sector, has been an important contributor to the bothersome decline in semiconductor orders that began late last summer and is expected to continue in 1989.

More uncertainty arises as Europe steps up its preparation for the coming unification of the European Economic Community in 1992. The full brunt of this development will not be felt in 1989, but preparations to deal with this new large, homogeneous market entity will no doubt



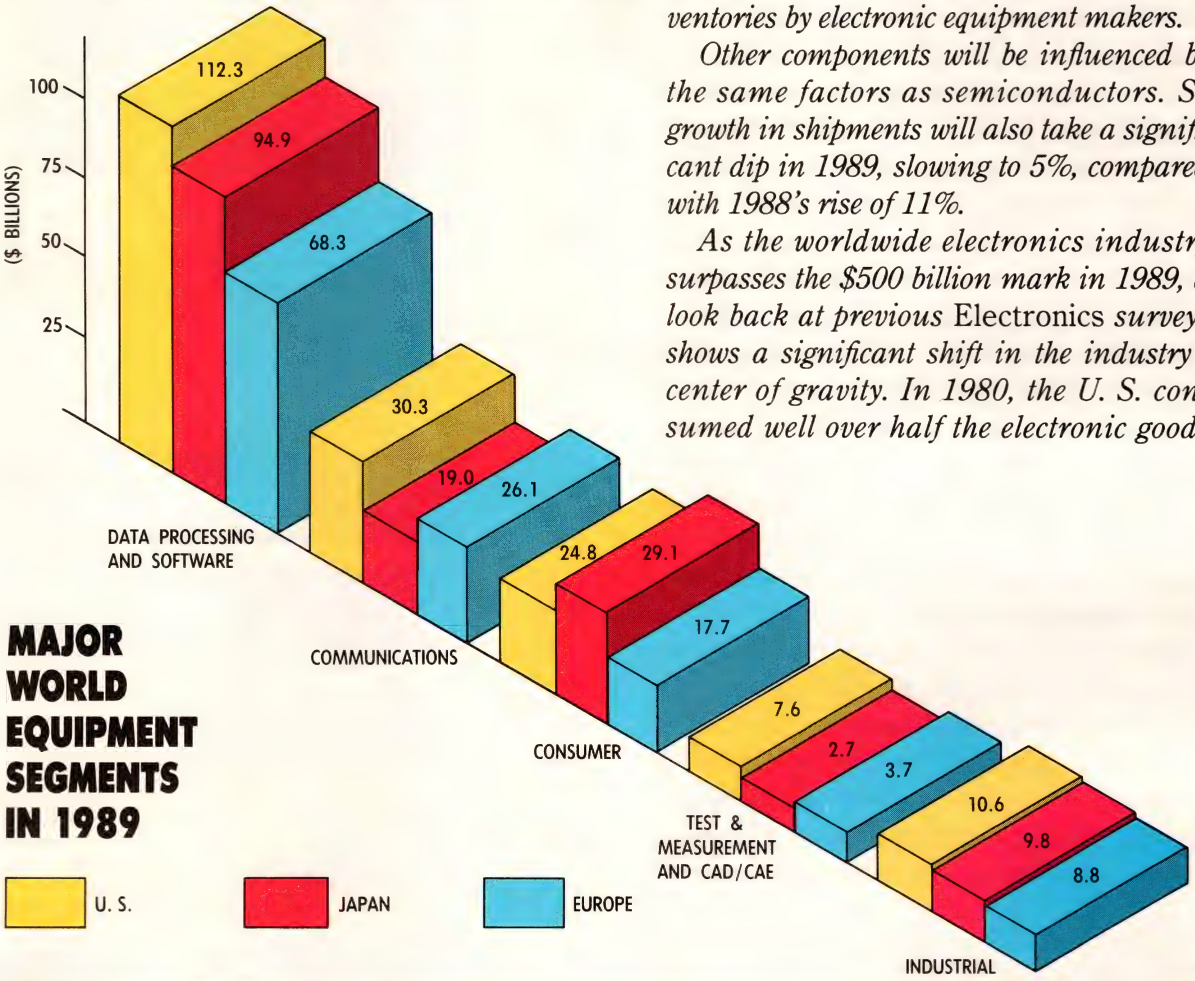


preoccupy European, U. S., and Japanese competitors over the next few years.

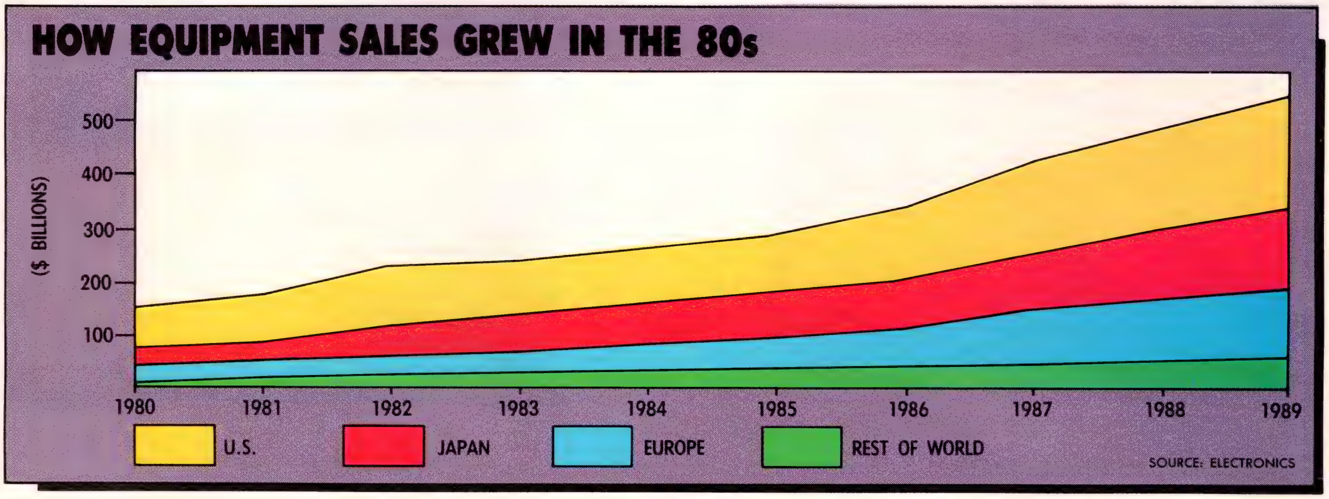
The worldwide semiconductor industry, after enjoying one of the best growth years in its history—28%—is looking ahead to a year of only moderate growth of 10%. Last year's shortages in dynamic random-access memories and 32-bit microprocessors boosted average selling prices and swelled the coffers of chip vendors. Now those shortages have all but disappeared. The result is lower prices and reduced stockpiling of chip inventories by electronic equipment makers.

Other components will be influenced by the same factors as semiconductors. So growth in shipments will also take a significant dip in 1989, slowing to 5%, compared with 1988's rise of 11%.

As the worldwide electronics industry surpasses the $500 billion mark in 1989, a look back at previous Electronics *surveys shows a significant shift in the industry's center of gravity. In 1980, the U. S. consumed well over half the electronic goods*



MAJOR WORLD EQUIPMENT SEGMENTS IN 1989



HOW EQUIPMENT SALES GREW IN THE 80s

SOURCE: ELECTRONICS

produced in the world. But since then the U. S. has steadily lost ground to Japan, which now accounts for almost a third of electronics consumption.

The major instrument for deriving the information in the 1989 Electronics *market forecast was a questionnaire sent to executives of companies that make equipment or components listed in the survey. The poll was taken in the final three months of 1988. Supplemental interviews by* Electronics *editors were made to resolve ambiguities and derive an industry consensus.*

Summing up, the Electronics *forecast indicates that 1989 will not be remembered as a banner year for the maturing industry, but it will be a post-boom year that promises to finally break the markets from the steep bust cycles that have caused havoc for manufacturers. If no unforeseen catastrophes occur,* Electronics' *consensus predicts there will be no recession in 1989—but the question still remains for 1990.*

CREDITS

ELECTRONICS *offers thanks to the many hundreds of individuals and companies who provided data for this forecast. In particular, we acknowledge the cooperation of the following organizations: • Analytics • Associazione Nazionale Industrie Elettrotecniche & Elettroniche • British Radio & Electronic Manufacturers Association • Bureau d'Informations et de Previsions Economique • CAP International Inc. • Ceeris International Inc. • Dataquest Inc. and Dataquest UK Ltd. • Disk/Trend Inc. • Electronic Components Industry Federation • Electronic Engineering Association • Electronic Industries Association and the EIA Consumer Electronics Group • Electronic Trends • Elsevier BEP Ltd. • Forward Concepts Inc. • Freeman Associates Management Consulting • The Freedonia Group • Frost & Sullivan Inc. • GAMBICA • Gartner Group • Groupement des Industries Electroniques • Harbor Research Corp. • Henderson Ventures • InfoCorp • Interconnection & Packaging Council • Integrated Circuit Engineering Corp. • International Data Corp. • National Computing Centre • Prime Data • Printed-Circuit Association • Projection 2000 Ltd. • Salzer Technology Enterprises Inc. • Semiconductor Technology Center • Tech Tran Consultants Inc. • Technology Research Group • Teknibank SpA • VLSI Research Inc.*

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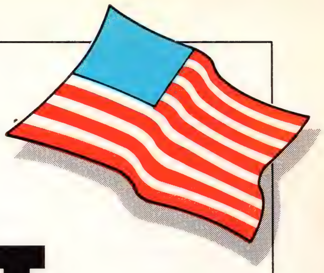


THE PC JUGGERNAUT BOGS DOWN

As it wrestles with consumer confusion and demands for less costly, easier-to-use, open systems, the U. S. computer industry is looking ahead to a year of only modest growth. The growing sluggishness of the personal computer segment in particular, even as it surpasses mainframes to become the industry's biggest, is cited by analysts observing semiconductor and other component markets as a primary cause of market softness.

This year's unexciting prospects represent a continuation of a trend toward dipping growth rates that's hit the overall data-processing market in the past two years. In 1987 the industry enjoyed a 15% rise over its 1986 totals, but in 1988 growth slowed to 10%. And this year the rise will be lower still, just 7%, the *Electronics* consensus survey predicts.

However, the U. S. computer-systems market is huge, and 7% growth represents a lot of equipment changing hands—$61.3 billion worth in 1989. That total brings the overall data-processing hardware market to $86.8 billion, *Electronics* predicts, against last year's $81 billion. (Some of the data-storage and input/output equipment, as well as terminals, is probably counted twice, since part of it may be included in the systems estimates as well.)

As the market ebbs and flows, there are many undercurrents at play. The industry is undergoing important changes in structure, with some venerable product categories rapidly losing market share and new groups coming on strong. For example, midrange proprietary systems are dropping fast. At the same time, multiuser microprocessor-based systems using open software are growing, and work stations are zooming ahead in unit sales, if not in revenue.

As for PCs, sales into the U. S. market were expected to reach $17.6 billion at year's end, against $17.5 billion for mainframes. Since together these two categories dominate the computer business, the outlook for them is crucial to that of the market overall. *Electronics* projects 8% growth for PCs—after 15% in 1988—and 5% for mainframes, figures that roughly reflect the fortunes of the computer industry as a whole.

Along with the changing lineup of product categories comes a change in the players' roster. Some new vendors are thriving while many veterans are struggling to survive. For example, Compaq Computer Corp., an upstart of the '80s, is now a solidly established vendor in the desktop and portable-computing market, racking up impressive revenue and profit gains every quarter. And Data General Corp., a stalwart in the minicomputer marketplace, is struggling for small gains as it tries to supplement its proprietary minicomputers—the market for which is stagnating—with new microprocessor-based open systems.

DATA PROCESSING EQUIPMENT

	(millions of dollars)		
	1987	**1988**	**1989**
Computer systems, total	**52,373**	**57,436**	**61,264**
Personal computers	15,280	17,570	18,980
Microcomputers, total	6,350	6,874	7,372
Technical work stations	1,800	2,124	2,272
Multiuser, business/personal	4,550	4,750	5,100
Minicomputers	2,815	3,012	3,222
Superminicomputers	10,600	11,600	12,300
Minisupercomputers	128	170	275
Supercomputers	700	720	750
Mainframes	16,500	17,490	18,365
Data-storage devices, total	**5,625**	**6,617**	**7,585**
Fixed disk drives, total	3,747	4,654	5,479
Up to 100 Mbytes	2,059	2,115	2,344
100 to 1,000 Mbytes	1,197	1,843	2,296
Over 1,000 Mbytes	491	696	839
Flexible disk drives, total	821	802	870
8-in.	60	28	9
5-1/4-in.	444	382	326
3-1/2-in.	317	392	535
Optical-disk drives, total	89	172	239
Read-only	26	39	54
Read/write	63	133	185
Cassette and cartridge magnetic-tape drives	331	390	422
1/2-in. cartridge-tape drives	34	102	153
Reel-type magnetic-tape drives	603	497	422
Data terminals, total	**4,740**	**5,000**	**4,780**
CRT terminals, total	3,820	3,990	3,710
ASCII text terminals	2,370	2,500	2,390
Graphics terminals, total	1,450	1,490	1,320
Monochrome	800	690	500
Color	650	800	820
Job-entry terminals	920	1,010	1,070
I/O peripherals, total	**10,408**	**11,902**	**13,181**
Computer-output microfilm	179	150	130
Digitizers, graphics tablets, light pens, track balls, & mice	240	268	297
Optical scanning devices	720	828	878
Plotters	800	900	950
Printers, total	8,469	9,756	10,926
Monochrome printers, total	8,020	9,219	10,291
Impact	4,923	4,820	4,748
Nonimpact	3,097	4,399	5,543
Color printers, total	449	537	635
Impact	243	262	280
Nonimpact	206	275	355
DATA PROCESSING EQUIPMENT, TOTAL	**73,146**	**80,955**	**86,810**

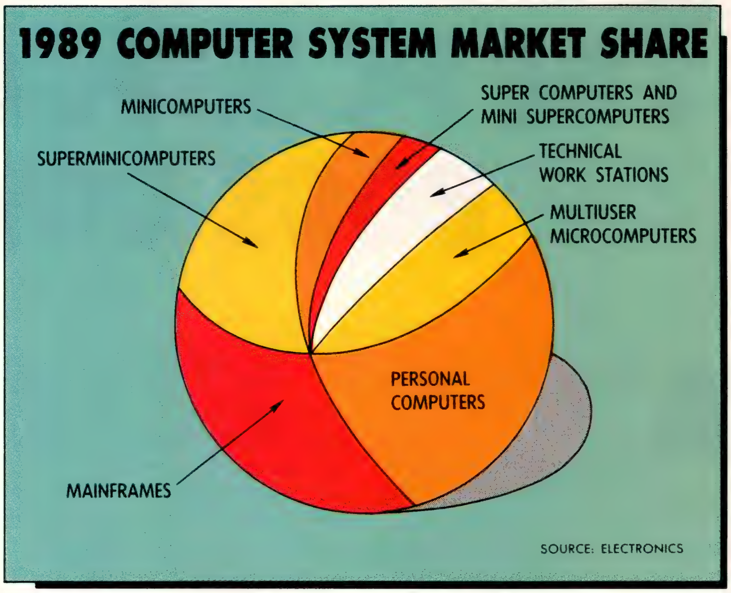
All figures in current U.S. dollars.

Such shifting fortunes resulted last year in the consolidation of companies, and this trend is likely to accelerate in 1989 as companies indulge in a merger-and-acquisition binge. For example, Unisys Inc., the company created by the merger of Burroughs and Sperry, recently acquired Convergent Technologies, while Masscomp merged with Concurrent Computer.

To rise to the top in such a volatile corporate landscape requires extra attention to meeting customer needs. This year, users are clamoring for open systems and industry standards. They want to get their computing jobs done as easily and economically as possible, and computer makers are hustling to measure up. "Successful vendors will be those that are perceived to be on the users' side," says William N. Bonin, vice president of North American Operations at X/Open Ltd., San Francisco. "Open-systems computing offering source-code compatibility across many vendors' products will help to create that perception."

In fact, proponents of open systems—and there are hardly any vendors left who are not—claim that the ability to transfer and run applications easily among computers from a variety of vendors will give the whole market a big boost. They point to the boom in PCs and software compatible with IBM Corp.'s original, and the impact on the industry as that architecture establishes itself as a de facto standard.

Also contributing to strong new product cycles are two additional trends: an equally fast evolution to high-performance VLSI processors and the growing tight integration of PCs into hierarchies that include corporate mainframe systems and departmental computers. Historically, business booms when plenty of new products are being introduced in any given segment of the computer market. This year, the flood of new products being prompted by open systems, VLSI technology, and networked hierarchical systems will keep the computer market perking.


1989 COMPUTER SYSTEM MARKET SHARE

SOURCE: ELECTRONICS

PCs HAVE SURPASSED MAINFRAMES AS THE LEADING SEGMENT

In older market areas the pace is slower. Mainframes, for example, continue their modest pace: they will grow only 5%, the *Electronics* survey has found, which is a little below the 6% or 7% typical of this category. Sales should be $18.4 billion, compared with $17.5 billion last year. In the early part of 1988, mainframe sales shot up, thanks to a buying binge that had been postponed after the Oct. 19, 1987, stock market crash. But this burst of activity did not last.

"We are disappointed by the continued industry weakness in our U. S. markets," says W. Michael Blumenthal, chairman and chief executive officer at Unisys in Detroit. "Given the uncertain U. S. computer market and a tight defense budget outlook, we are building a conservative plan for 1989 that assumes double-digit earnings growth on single-digit revenue growth."

Also experiencing slower growth than the market overall is the traditional minicomputer. The vendors of these proprietary 16-bit and low-end 32-bit systems have been accustomed to far outpacing the rest of the industry, historically racking up double-digit growth. But in the past two years, the minicomputer segment has grown only as fast as mainframes. The *Electronics* survey pegs 1989 growth at 7%, with sales of $3.2 billion.

Minicomputers are being beaten soundly in terms of price/performance ratios by newer systems built with powerful microprocessors—among them the 32-bit conventional architectures such as Intel's 80386 and Motorola's 68030, as well as reduced-instruction-set architectures, such as Sun Microsystems' Sparc and the system from MIPS Computers. Another competitor is the modular multimicroprocessor system, such as those from Encore Computer, Pyramid Technology, and Sequent Computer, which offer high price/performance and convenient growth in easy stages. However, the minicomputer market is so large that it still has much momentum and will not dissappear overnight. This year's projections are for minicomputers to rise 7%, to $3.2 billion, and superminicomputers 6%, to $12.3 billion.

The good news in midrange computers is the speed with which the Unix operating system is being adopted for multiuser transaction-processing and mission-critical business systems. As a result, computer systems based on Unix and other open-systems standards are showing rapid growth. The Unix-based multiuser market worldwide is expected to rise anywhere from 25% to 50% each year for the next two years, market watchers say.

In supercomputers, the market is broadening and the forecast wide-ranging, depending on which varieties are considered. There are three categories of these machines emerging: minisupercomputers at the low end; midrange supercomputers like the Convex Computer Corp. C200 Series and some of the machines made by Control Data Corp.'s ETA Systems divsion; and the high-end systems made by companies like Cray Research, ETA, and three major Japanese computer companies. The *Electronics* survey groups the low-end and midrange systems as minisupercomputers, and finds this category zooming ahead by 62% in 1989 to $275 million, nearly doubling last year's 33% growth rate. At the same time, high-end supercomputers will inch ahead with only 4% growth to $750 million.

"The new presences in the [high-end] market—Japanese companies and ETA Systems—complicated by product-cycle issues—all make it hard to predict revenues in the next couple of years," says Gary Smaby, managing director at Needham & Co. in Minneapolis. Particularly troublesome are "the product transitions at [industry leader] Cray," which is working on a GaAs-based design for its next-generation product.

Meanwhile, says Smaby, "the low end [of the market] is beginning to stratify, with one company, Convex, clearly moving away from the pack and the weaker players finding small niches and digging in." This is good news in Richardson, Texas, where Convex expects "another dramatic year ahead; we are extremely bullish," says Robert J. Paluck, president and CEO. Analysts are projecting at least 50% revenue growth for Convex, which has become chief supplier to the commercial scientific market.

For another scientific category—technical work stations—the heady growth of the recent past is leveling off this year, at least in terms of revenue. The *Electronics* forecast pegs an increase of only 7%, compared with 18% last year and a whopping 47% in 1987. Total U. S. sales are expected to top $2.27 billion, up from $2.12 billion in 1988.

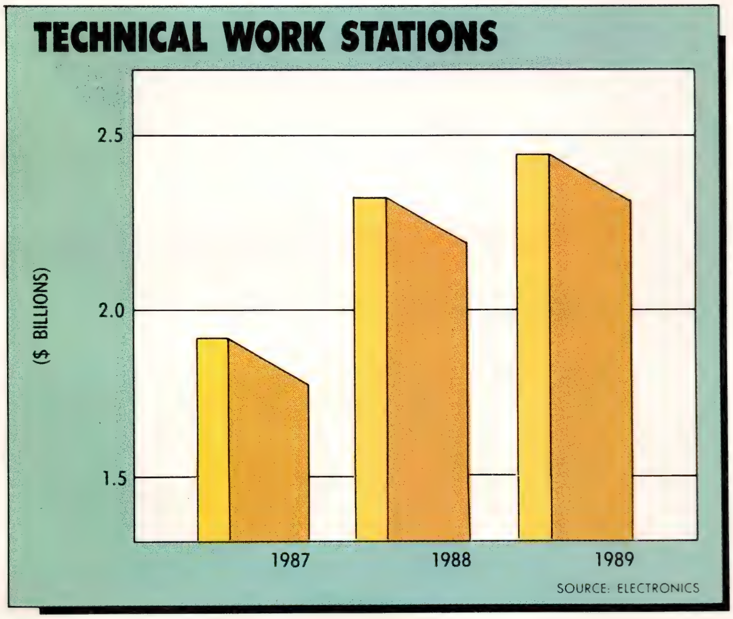
A good portion of the slowdown in revenue stems from a fiercely competitive market that is driving prices steeply downward and trimming margins to the sticking point. This market is still a bloody battleground, with leaders Apollo Computers and Sun Microsystems spilling most of the blood. But other vendors are also starting to ax prices. In November, for example, Tektronix Inc. slashed its work station prices by 20% and Hewlett-Packard Co. introduced a new entry-level machine at just $5,495—a PC price level. The improved price/performance ratio, though, is keeping unit growth in the range of 20% to 30%.

New products will keep the technical work station market bustling. Until now, these machines have been primarily based on the Motorola 68000 microprocessor family. That is beginning to change. "RISC is a coming trend at the high end, and the 386 is coming up from the bottom," says Carl Flock, work station analyst at Dataquest Inc. in San Jose, Calif. "There will be introductions of 68030 work stations through this year, but 88000 and Sparc architecture introductions are coming, too."

It is clear that the personal computer market is maturing and that although annual growth rates are slowing down, they're doing so from a much bigger base. So absolute growth is still large. And some segments and application areas, such as desktop publishing and portable computers, are growing at the old, exhilarating pace. The market for 386 and 286-based PCs running Unix is starting to grow and will soon be a significant market force.

Overall, the PC segment, the largest single unit in the *Electronics* computer-system survey, is expected to grow by 8% in 1989 to $19 billion. The drop in growth from 1988's 15% can be attributed to price erosion at the low end, a market already too large to continue such rapid expansion, and some degree of expected sluggishness in buying.

In the longer term, though, the PC market retains its bright prospects, and growth should continue for the three emerging subsegments. The low-end AT-compatible machines are still in big demand, and growth in unit sales will remain stable even as price pressure moderates revenues.



SHIPMENTS ARE UP BUT REVENUES DOWN IN WORK STATIONS

The high-performance segment—those machines based on the 386—should remain strong in both units and dollars, as prices appear to be holding up and power users and major corporations embrace higher-performance desktop computing.

And a new subsegment of the PC market that will start stirring things up in the next two to three years as 386-based PCs break into the Unix market. "The next major growth in the PC market may come from Unix," says Michael Curran, general manager of Micro Industries, a custom PC and system maker in Westerville, Ohio. "A lot of companies with 386, and even 286, Unix systems are coming to market."

Besides computers, the data-processing market includes a variety of peripherals. In data-storage devices, the 1989 market is mixed, with the newer technologies generally enjoying larger growth rates than their mature brethren, but from a smaller market base.

In rigid disk drives, the market is still growing, albeit a little more slowly than in the recent past. *Electronics* projects that for 1989, U. S. consumption will be $5.5 billion, up 18% from last year's $4.7 billion. But that is below the 24% growth of 1988. Indeed, the flattening trend should continue for the next three years, according to Disk/Trend Inc., the Mountain View, Calif., market research firm. Disk/Trend forecasts average revenue growth during that time at just 14.5%—considerably lower than the 20% to 30% of the past.

The downturn, and the difficulty it's creating for some manufacturers, is attributed by many industry observers to excess capacity in the marketplace. This results in severe price pressure. The short product cycles and product changes coming fast and furiously in this market have hurt those vendors who had trouble keeping up with the rapid transition to smaller-diameter drives with higher recording densities and capacities.

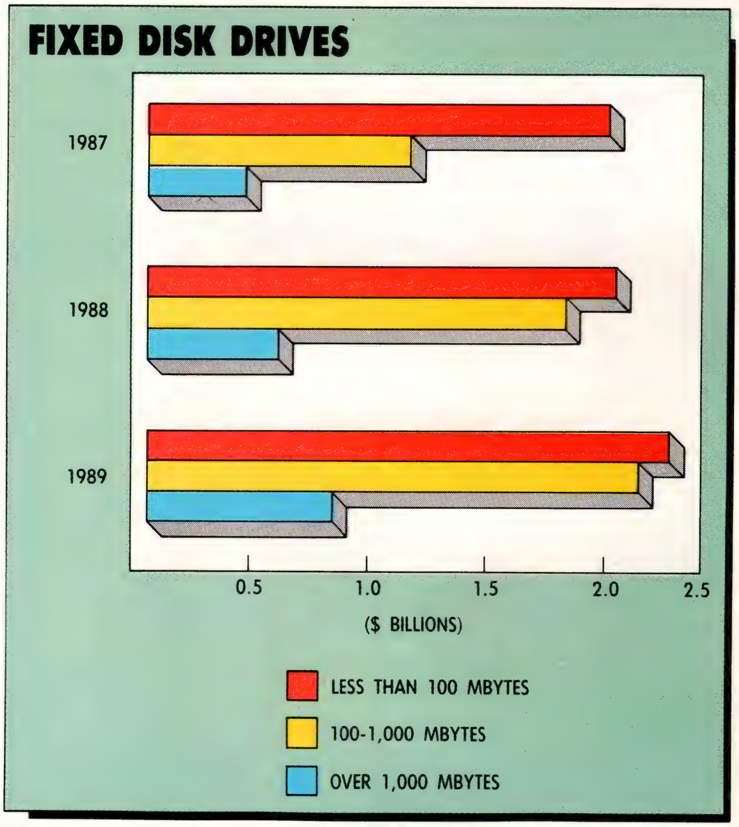
In terms of form factor, the 3.5-in. drives have virtually swept away most of their larger counterparts. By 1991, they should account for fully 98% of worldwide unit shipments of 30- to 60-Mbyte drives, 94% of the 60- to 100-Mbyte drives, and 84% of 100- to 300-Mbyte drives, according to the Disk/Trend Report.

In flexible disk drives, too, the most noticeable change is the continued phasing out of the large form factors. The 8-in. drives are industry dinosaurs—very few will be made by the end of 1989 and U. S. sales will drop to $9 million, the *Electronics* survey has found. And even the now-ubiquitous 5.25-in. drives are starting to diminish in the market as the popular 3.5-in. disks gain strength. Last year, for the first time, the market for these smallest flexible drives caught up with the 5.25-inchers and ended the year ahead by a small margin: the U. S. market was $392 million, compared with $382 million for 5.25-in. drives. In 1989, the smaller drives will pull way ahead, growing 37% to $535 million, and the 5.25-in. drives will decline 15% to $326 million.

The new kids on the block are optical-disk drives, and the market for them is just starting to grow. The *Electronics* survey forecasts U. S. sales of all types of optical drives at $239 million this year, a 39% gain over last year's $172 million. The advent of erasable drives is giving this market a healthy push.

In tape drives, all categories will be slowing down this year. That's because using tape drives as backup devices for files on small computers—PCs and work stations, primarily—has not caught on. Also, with the growth of networks with centralized file servers, users find it more economical to put a large-capacity backup device on the file server rather than supply one for each machine. Overall, this category will grow 8% to $422 million. ☐

U.S. MARKET REPORT



STRONG YEAR AHEAD: 22% GROWTH SEEN

In a year when much of the electronics industry could be wearing a hangdog expression, at least one market segment looks to be bright-eyed and bushy-tailed: software. Revenue from computer software of all kinds should continue strong in 1989, topping $25.5 billion, the *Electronics* consensus survey has found. That's an increase of 22% over 1988's $21 billion, a welcome performance in a year with many managers fretting about a possible downturn in the U. S. economy.

Indeed, growth is declining in almost all portions of the computer hardware sector. Computer users, industry observers point out, are assimilating technology they've already purchased. But as they do, they're discovering new software they can profitably use on their personal computers, networked work stations, and other systems. Software that puts high-octane fuel in those new computer engines is coming to market.

As a result, *Electronics* forecasts that applications programs of all kinds will grow almost 19% this year: from $5.7 billion to $6.8 billion. Applications tools, including data bases, computer-aided design and engineering programs, desktop publishing, and the like, will rise 21%, from $4.8 billion to $5.9 billion. And sales of system utilities, including operating systems, will be up 24%, from $10.3 billion to $12.8 billion. These growth rates closely parallel those of 1988, which marked a 20% overall rise above 1987.

The Unix operating system continues to rock along, despite a course divergence between backers of AT&T Corp.'s System V and those supporting the Open Software Foundation. This market should grow at a compounded annual rate of 25% through 1992, says Vicki Brown, senior analyst at International Data Corp., the Framingham, Mass., market research firm. That would put the U. S. portion of revenue from Unix-based systems—not the unbundled operating-system software itself—at some $6.67 billion this year, with IDC projecting $13.9 billion by 1992.

SOFTWARE

(millions of dollars)	1987	1988	1989
Applications programs (word processing, accounting, etc.), total	4,725	5,720	6,808
Applications tools, total	4,014	4,840	5,893
Data bases	1,974	2,350	2,770
CAD/CAE/CAM (except electronics design)	1,240	1,365	1,480
Desktop publishing	455	637	955
Artificial intelligence	290	420	588
Image processing	55	68	100
System utilities (operating systems, debugging & diagnostic tools), total	8,622	10,346	12,830
SOFTWARE, TOTAL	**17,361**	**20,906**	**25,531**

All figures in U.S. dollars

Besides Unix, another factor contributing to the software boom is the resolution of some uncertainties that slowed the PC market last year. Those include the availability of Microsoft Corp.'s OS/2 operating system, complete with the Presentation Manager graphical user interface, and indications that IBM Corp. is softening an earlier hard line on licensing its Personal System/2 Micro Channel.

The IBM development could spur PS/2 clone makers stymied over worries about how zealously Big Blue would protect its patents. As for OS/2, "there's an incredible amount of application development going on," says Mark Mackaman, OS/2 product marketing manager at Microsoft in Redmond, Wash. "We've shipped more than 4,500 development kits." The first wave, he says, will be systems that adapt popular MS-DOS packages to OS/2. But he expects that by midyear, some 15 to 25 packages will debut incorporating the Presentation Manager.

Another PC-related development is the emergence of business or presentation graphics as a formidable segment. "This will be the year presentation graphics joins the big three—word processing, spreadsheets, and data bases—as a significant PC software category," says Fred Gibbons, president of Software Publishing Corp., Mountain View, Calif. "This is going to be a billion dollar business" in the not-too-distant future.

Significantly, Software Publishing, whose applications packages have been predominantly MS-DOS-based, will spend 17% of its 1989 research budget on the Macintosh, Apple Computer Inc.'s PC, which continues to gain in graphics and imaging applications. Apple "really leans on the Mac's graphics and imaging strengths," says analyst Fred Thorlin at Dataquest Inc., the San Jose, Calif., market researchers. He looks for the Mac II to find new vigor in "desktop advertising" applications, among them video post-production processing. □

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DATA NETS LEAD SECTOR TO 10% RISE

Fueled by the networking boom, the U. S. data communications market will soar 18% this year to $5.8 billion, the *Electronics* consensus survey has found. This powerhouse performance outpaces the 15% achieved last year, when revenues reached $4.9 billion, and tugs the overall communications market into a 10% growth curve. In total, this highly fragmented market will see $30.3 billion in sales, against last year's 10% rise to $27.6 billion, *Electronics* projects.

Industry watchers expect networking equipment to grow at a 25% to 30% clip, with wide-area network applications rising faster than those for local-area nets. Fiber-optic equipment will benefit from networking's popularity: *Electronics* predicts an increase of 16% to $780 million, nearly quadruple the growth rate in 1988, when revenue totaled $670 million. Facsimile-machine sales will continue to steam along, scoring a 22% rise to $2.2 billion on the heels of a 61% gain to $1.8 billion last year. On the other hand, mature technologies such as telecommunications systems, television, and radar will sustain low to moderate gains in the 4% to 8% range.

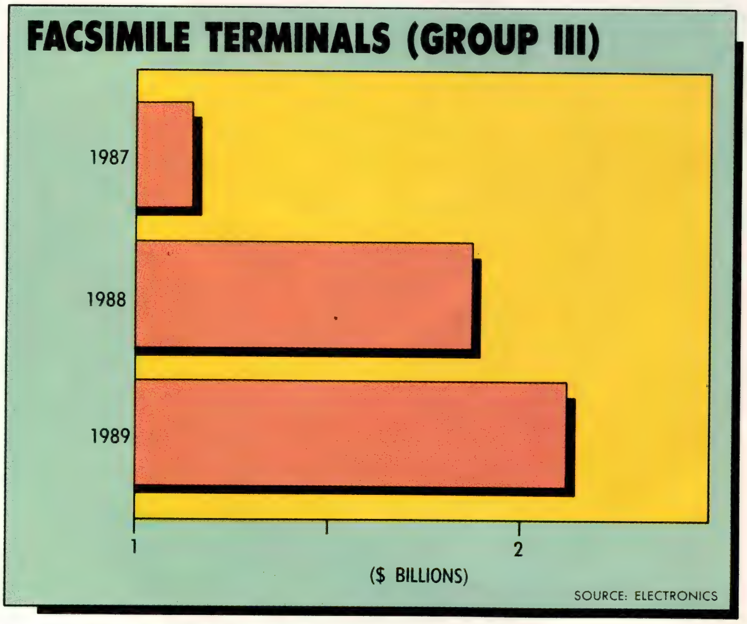
Driving the expansion of LAN and WAN markets is the large installed base of personal computers teamed with the firm perception in management circles that linking those machines will mean crucial productivity boosts. This year will see the emergence of significant differentiation in the networking market, says Peter Simon, vice president of marketing at Banyan Systems Inc., Westboro, Mass. He expects that LANs will grow 25% to 30% as more sophisticated organizational networks spiral upward at twice that rate.

"Over the past couple of years," says Simon, "large corporations have gone beyond putting five or six PCs together to share a server. We're seeing much more interest in organizational computing and wide-area networks." Banyan Systems estimates that large companies have a population of about three million PCs that could be connected into organization-wide networks and "something less than 20% of them are part of networks" at this time, says Simon. By contrast, approximately one-third of the seven million PCs that could be connected into LANs have been. Growth is expected to spurt ahead faster in organizational networking because instead of hooking up computers 10 at a time at the work-group level, a single company might link two buildings and hike the interconnected PC total by 1,000 or more, he says.

Networking is driving the fiber-optic equipment market to a range between 10% and 25%, depending on market segments, says Hal Spurney, director of marketing at Fibronics Inc., Hyannis, Mass. Enhancing copper-wire networks with a fiber-optic backbone will account for the bulk of fiber networking sales in 1989 and 1990.

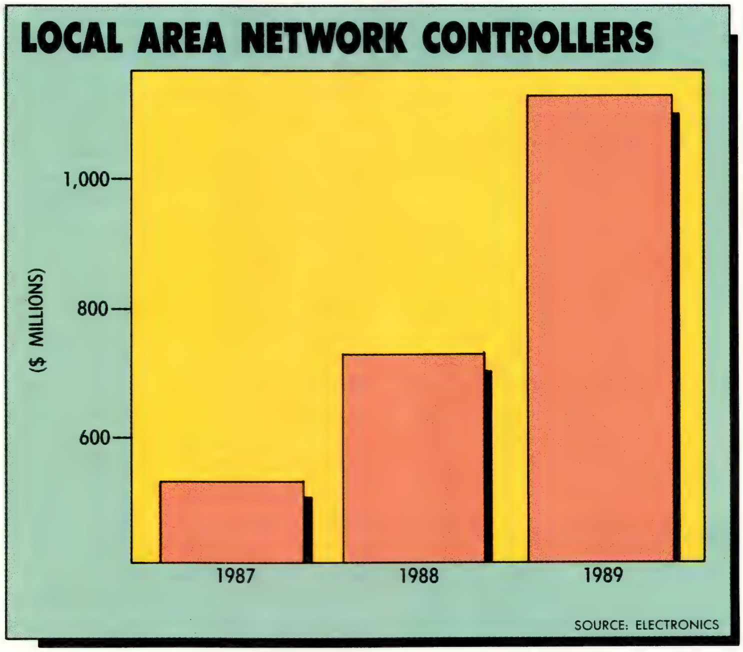
But the Fiber Distributed Data Interface standard will get a big push from the introduction of Advanced Micro Devices Corp.'s FDDI chip set, says Spurney. Besides greatly reducing the cost of the electronics needed to implement FDDI network, it also offers a standard solution that practically guarantees interoperability among products from different vendors. "Customers are no longer looking at fiber as a so-

FACSIMILE TERMINALS (GROUP III)



SOURCE: ELECTRONICS

lution of last resort," he says.


LOCAL AREA NETWORK CONTROLLERS

SOURCE: ELECTRONICS

The market for fiber-optic cable itself will probably level off, though, says Spurney. That's because the only large replacement market remaining is twisted-pair wiring, and that network segment does not require high-speed capability.

Modems, which have been the traditional wide-area data link for many companies, will be adversely affected by networking's evolution toward more sophisticated and powerful systems. Price competition will also hurt dollar volumes, and *Electronics* forecasts a meager 3% growth rate to $1.9 billion. That's a big drop from last year's 11% hike. Indeed, says George Grumbles, president of Universal Data Systems Inc., Huntsville, Ala., modem-market revenue will be growing over the next two to three years, "but not in an astonishing way. I expect U. S. revenue to be up a few percentage points, but certainly not in the double digits." The number of units shipped will be up significantly, he says, but competition will force prices down even more precipitously.

Grumbles expects shipments of low-speed modems to shrink, while the half-duplex 9600 bits/s units being used in switched networks should hold their own and the 9600s used in private networks should dip significantly. "The V.32 market seems to be the spot where most everybody is hanging their hats in terms of growth," he says. "In 1989, I expect there will be about 250,000 units shipped by all U. S. manufacturers."

The essentially flat market prospects for modems is repeated in many other types of data communications equipment, such as multiplexers and concentrators, which are also known as statistical multiplexers. *Electronics* is forecasting about 5% growth in both these categories, to $1.2 billion for multiplexers and $400 million for concentrators. But there are bright spots within each category, depending on application.

Perhaps the most luminous is the T1 multiplexer and associated equipment that delivers 1.5-Mbit/s voice and data communications, says Joe Bulsak, director of product marketing at Infotron Systems Corp., Cherry Hill, N. J. This segment is expected to grow at 12% this year, he says. Sales of concentrators, packet switches, and other equipment in what Bulsak calls the "access market"—data only up to 56 Kbit/s—will also grow steadily, rising from a range of around $575 million in 1989 to nearly $700 million in 1992, says Bulsak.

Another fast-growing product is packet switches, says David Woodall, assistant vice president for product marketing at Timplex Corp., Woodcliff Lakes, N. Y. These devices now constitute a $450 million to $470 million market and will grow at a 20% annual rate, he says. Packet switches perform essentially the same function as statistical multiplexers, and the packet switches are stealing market share because they offer all the benefits of using an international standard—in this case, CCITT's X.25. "There's a general interest in migrating to standards," says Woodall, "and X.25 also has a richer and more robust feature set than the proprietary systems."

However, there's a snake in the garden, says Morey Ejabat, vice president for wide-area networking production at Micom Systems Inc., Simi Valley, Calif. While he agrees that X.25's popularity will erode concentrator sales, he believes that intense price competition will result in overall dollar volume slipping by 5% to 10% next year as unit shipments rise slightly.

But no slippage is foreseen for T1 mulitplexers, says George Fritkin, vice president of Micom's Switching and Connectivity Product Group. The market will benefit from a move to point-to-point connectivity products such as local and T1 multiplexers, which Fritkin expects to grow at 10% to 15% this year. The impetus, he says, is the need to upgrade communications speeds to match processing speeds. Another force driving the point-to-point market, he says, is the growth in LANs, which are being connected by gateways.

Also assured of strong growth are facsimile machines, which should end 1989 with a 22% gain and $2.2 billion in revenue, according to the *Electronics* forecast. That performance comes off a 61% growth rate in 1988, when sales reached $1.8 billion. "The fax machine has crossed into the list of essential office equipment along with the phone, copier, and typewriter," says

Judy Pirani, senior market analyst at CAP International Inc., Norwell, Mass. The low end of the Group III facsimile market, which constitutes about 40% of the units sold, will account for most of the market growth, she says.

As rosy as Pirani's view is for facsimile, Joe Cosgrove, national marketing manager of Sharp Electronics Inc.'s Facsimile Division in Mahwah, N. J., has a rosier one. For the past three years, facsimile sales have grown at an annual rate of 100% to 120%, he says, and there's no reason for that to abate in 1989. "Some analysts are forecasting a fall-off to 30% or less," he says, "but I don't see the curve flattening that fast."

COMMUNICATIONS

(millions of dollars)	1987	1988	1989
Data communications, total	**4,265**	**4,898**	**5,600**
Concentrators	370	380	400
Front-end processors	845	890	960
Modems	1,650	1,840	1,900
Multiplexers	840	1,060	1,190
Local-area-network controllers	560	728	1,150
Facsimile terminals (including desktop), total	**1,130**	**1,825**	**2,220**
Fiber-optic systems, total	**640**	**670**	**780**
Radar systems, total	**5,400**	**5,710**	**6,160**
Radio, total	**4,248**	**4,655**	**5,216**
Amateur (mobile & base stations)	32	34	37
Aviation mobile (including ground-support systems)	179	202	221
Broadcast equipment	879	925	1,025
Land-mobile (mobile & base stations)	1,470	1,700	2,010
Marine-mobile (ship & shore stations)	182	197	226
Microwave systems (including antennas)	588	670	763
Satellite earth stations (excluding consumer)	918	927	934
Telecommunications systems, total	**7,785**	**8,045**	**8,356**
Switching systems	6,100	6,280	6,500
Telephones, total	1,685	1,765	1,856
Corded	1,038	1,020	1,040
Cordless	438	475	498
Integrated phone & answering devices	209	270	318
Television equipment, total	**1,720**	**1,839**	**1,970**
Broadcast	1,265	1,395	1,500
CATV	363	350	375
CCTV	92	94	95
COMMUNICATIONS EQUIPMENT, TOTAL	**25,188**	**27,642**	**30,302**

All figures in current U.S. dollars.

The next big market shift will come in three to five years, he says, and will be driven by an as-yet-unavailable technology that will reduce fax costs to $1,000 to $1,500 and use high-resolution laser printers and plain-paper copies. "Thermal paper is fax's biggest drawback," he says.

Group IV machines have been specified by the CCITT, but "there will be no real market for them until the integrated services digital network becomes pervasive," says Cosgrove. "They depend on a high-speed digital network, and right now it's much cheaper to send a fax with a Group III machine."

The snail's pace of ISDN is also affecting the telecommunications marketplace, which should record slow growth until ISDN becomes a reality in the mid-1990s. *Electronics* is forecasting only 4% growth to $8.35 billion, a near-repeat of last year's sluggish 3% gain. But Eric Nelson, director of market research for the Washington, D. C.-based North American Telecommunications Association, offers a slightly more optimistic forecast, seeing the overall communications equipment market expanding to about 10% growth in 1990. The largest single market segment—central office switches—will see a meager 3% gain in 1989 to $6.5 billion, *Electronics* projects, or may even decline, in Nelson's view. This is because the local exchange companies are still waiting for their inventory of analog switches to empty before starting to buy digital replacements, he says.

Private branch exchange systems will continue to be stymied by customer migration to the Centrex services offered by Bell Operating Companies, says Nelson. The PBX market is destined to stay more or less flat at $3 billion through the early 1990s, but will pick up later in the decade when ISDN protocols for customer-premises equipment are standardized.

Central office equipment sales will grow between 2% and 5% for the next few years, predicts Carl Griffith, director of product evolution at Northern Telecom Inc., Research Triangle Park, N. C. Although no new analog switches are being sold in the U. S., he adds, there is a continuing market for expanding the existing ones as new phone lines are added at the rate of 2% to 3% per year. As a result, "analog central-office-switch replacement has been going strong for the last few years."

In the telecommunications consumer arena, however, much stronger growth is being driven by the availablity of enhanced telephone technologies at affordable prices. Overall, telephones should rise 5% to $1.8 billion, *Electronics* projects, with the best performers the integrated answering machines/phones. These will climb 18% to $318 million. But sales of corded phones should level off, says Leslie Adams, manager of market planning at AT&T's Consumer Products Division, Parsippany, N. J. "Consumers are chosing cordless phones as the primary phone in their house," she says, "and they are stepping up to higher-priced models because of the high sound quality now available."

The integrated answering-machine market is also going upscale as purchasers buy models with more features. The increasing number of home offices has also spurred growth in this market, Adams says. Meanwhile, feature phones in the corporate market are growing, but not as fast as predicted. Prices have been stable in both corded and cordless phones, and retailers are seeing price erosion in stand-alone answering machines.

Radar markets are determined largely by big government orders, with equipment delivered four to ten years after the order is placed. *Electronics* forecasts 8% growth in this sector to $6.1 billion, a gain over last year's 6% rise. Richard Daley, director of radar equipment marketing for Raytheon Co., Marlboro, Mass., sees no slowdown in either conventional rotating-disk radar or the more advanced phased-array systems. □

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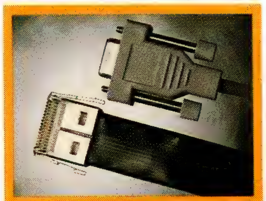

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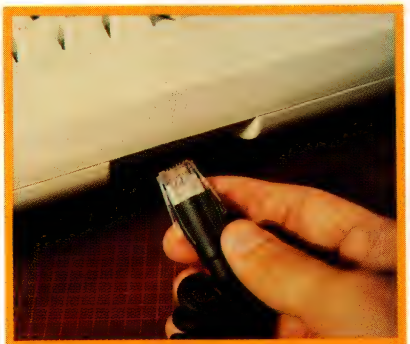

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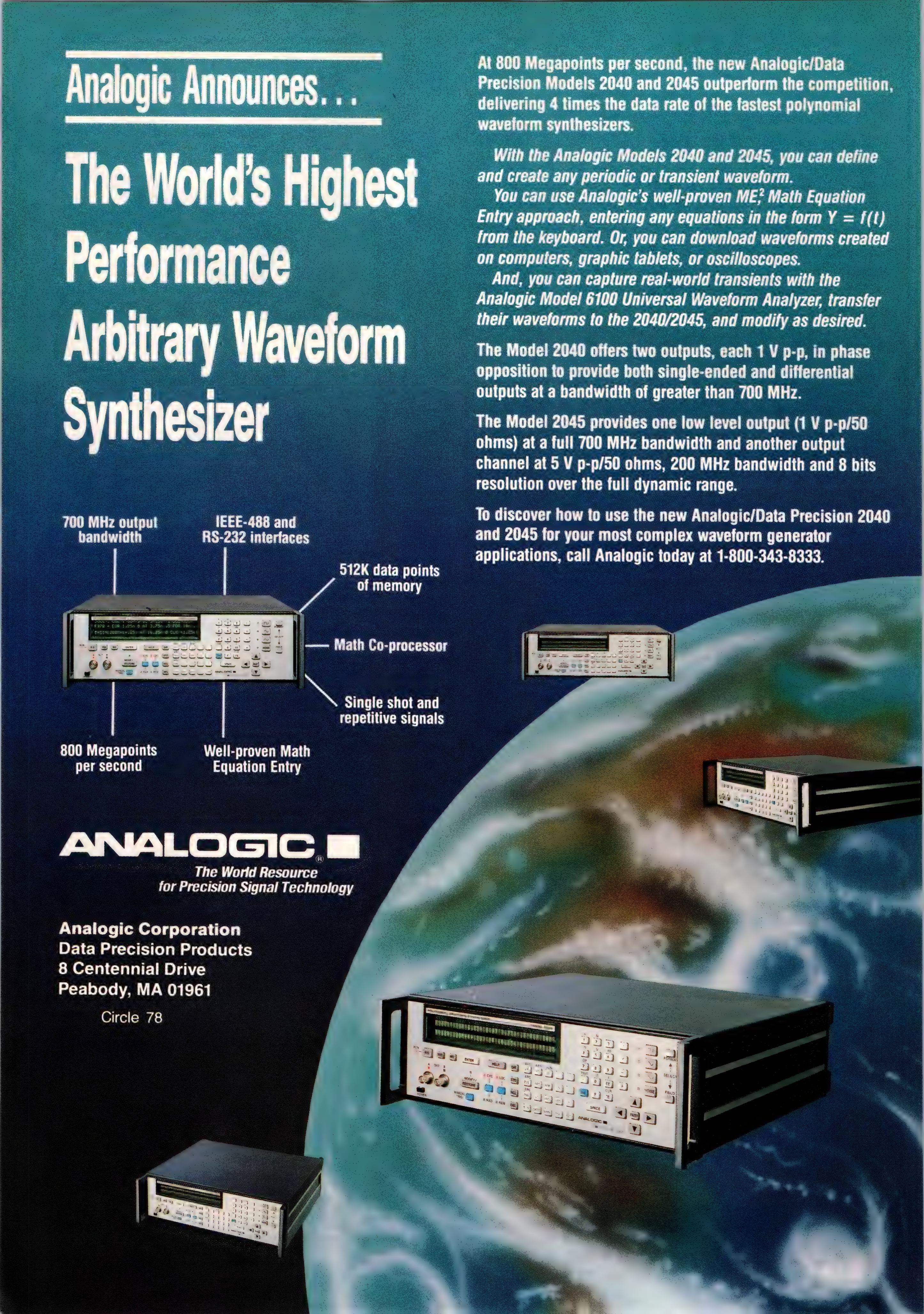

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LACKLUSTER MARKET HAS BRIGHT SPOTS

The U. S. market for test and measurement equipment, including high-ticket automatic test equipment, will probably see only mild growth in 1989, with the exception of a few small, hot markets riding current technology trends, like personal-computer-based instruments and verification systems for application-specific integrated circuits. Some types of ATE, notably memory and logic-chip testers, grew robustly last year, but the *Electronics* survey projects substantial weakening in those areas, in step with the slowed growth expected in semiconductors.

The total U. S. test and measurement market will reflect the expected softening of markets throughout the electronics industry; it is projected to grow only 9% in 1989 to $6.6 billion, following 13% growth in 1988. Growth in the market for big automatic test systems will probably drop from a heady 23% in 1988 to a still-healthy 10.5% in 1989, with the total domestic ATE market expected to reach $2.5 billion.

General test equipment, not including ATE, should hold nearly steady at about 8% growth (compared with 7.5% in 1988), to reach a total of $4.1 billion. Development systems are cooking along nicely at about 12% growth, thanks in part to the arrival of new software tools that use their in-circuit-emulation capabilities. Digital-oscilloscope sales are skyrocketing, as more features are offered at lower prices—but at the expense of analog-scope sales, with the net effect being a projected growth rate in 1989 for oscilloscopes no better than last year's. Nascent markets for ASIC verifiers and PC-based instruments are going with gusto, set to grow 50% and 36%, respectively. The brand-new market for VXI-bus card-based instruments will be getting off the dime in the next year or two, but 1988 sales in this area were insignificant.

Although most bread-and-butter U. S. markets will be relatively quiet, U. S. vendors of test and measurement equipment should do better than the domestic-market figures would indicate. Many companies report strong offshore sales that are due in the main to the weakening of the dollar in relation to other currencies, which makes U. S. instruments and systems cheaper to purchase in the Far East and in Europe.

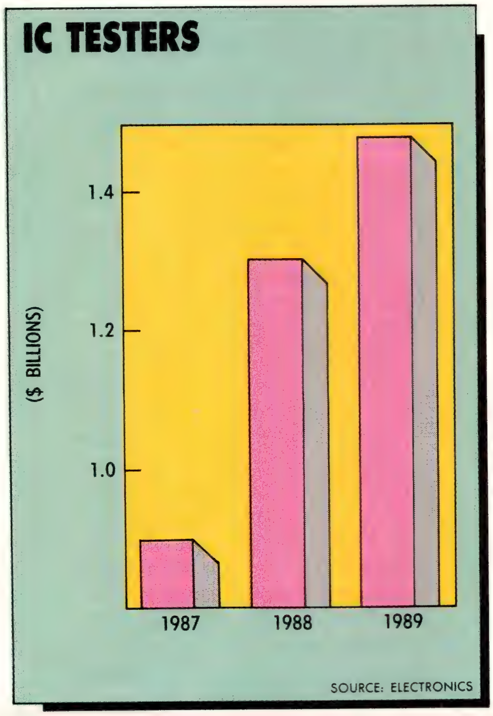
Pacific Rim countries scrambling to establish positions in the semiconductor and computer businesses have become eager buyers of high-technology U. S.-built test equipment, which gave U. S. vendors a boost in 1988 and will continue to do so in 1989. In Japan, the government is encouraging the purchase of U. S. equipment to ease the trade gap, and many U. S. companies have improved overseas marketing and customer support.

Makers of big ATE systems will need that overseas boost, because the domestic market will have the wind taken out of its sails in 1989 by the poor conditions expected in the semiconductor industry. Integrated-circuit tester sales leapt 37% in 1988, but are projected to grow only 11.5% in 1989 to $1.45 billion. "We expect the ATE market to experience a greater swing than the rest of the T&M market," says Galen Wampeter, president of Prime Data, a market-research firm in San Jose, Calif.

Indeed, "1988 was a good year for linear mixed-signal testers and memory testers," says James A. Prestridge, vice president of the component test group at Teradyne Inc. in Woodland Hills, Calif. Teradyne had a 200% increase in bookings in memory testers last year, largely 30-MHz testers. He says Teradyne expects bookings to fall off because of the large amount of capacity now installed.

But while shipments of

IC TESTERS



SOURCE: ELECTRONICS

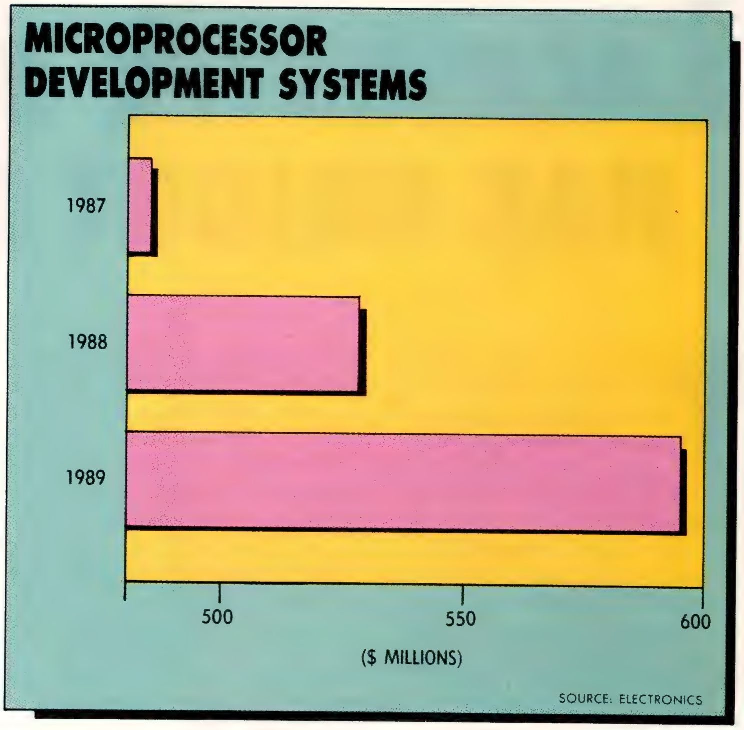
lower-performance systems are slowing, Prestridge says manufacturers are beginning to look for testers with 100-MHz test capability and the ability to test new mixed-signal (analog and digital) chips for television, integrated-services digital networks, and other markets. He looks to these buyers to offset declining purchases of hot-selling memory and logic testers.

As with the ATE market, the makers of bench and other test and measurement instruments are enjoying growth in foreign sales, thanks to the weak dollar and beefed-up overseas marketing. In the U. S., however, the product mix of broad-line suppliers will most likely see both ups and downs in levels of growth: some areas will probably wax in 1989 and others wane.

The best example is the U. S. oscilloscope market, which as a whole grew 8% in 1988 to $540 million. It is projected to grow slightly less, about 7%, in 1989. Yet there is a dramatic shift from analog to digital scopes, notes Chuck Small, product marketing manager at Hewlett-Packard Co. in Colorado Springs, Colo. Prime Data's figures back this assertion up. While digital scopes are projected to grow at 20% in 1989, the research firm says analog scopes will lose ground, slipping down 3% in 1989 after losing 2% in 1988.

"The digital oscilloscope is the fastest-growing instrument category," says Wampeter of Prime Data. "Not only is it replacing analog oscilloscopes, it is opening up new applications where analog scopes were impractical—in production test and automatic test systems—but where you can use the digital scope's intelligence and its logical triggering capability." By Prime Data's figures, digital scopes were nearly half of all scope sales in 1988. By the end of 1989, digital sales should exceed analog.

Digital oscilloscopes are taking off because they are offering greater function for less cost. For example, last year HP introduced its HP54510 scope, which sells for $3,465, about 30% less than the closest competitive product. "We achieved this low price by replacing boards of logic with chips," says Small.


MICROPROCESSOR DEVELOPMENT SYSTEMS

SOURCE: ELECTRONICS

THE DEVELOPMENT SYSTEM HAS RISEN FROM ITS ASHES, PHOENIXLIKE

The microprocessor development system, for its part, is a phoenix in full flight after having risen from its ashes. Development systems declined for several years because dedicated computers built into development system products were being replaced by general-purpose computers—PCs and work stations.

"Simulators running on a general-purpose computer can simulate the logic of a program running in a target computer such as a 68000," says Caine O'Brien, CASE product marketing manager at MicroCase Inc. in Beaverton, Ore. So there is no need for a special development system built around the target-system processor. "The development system instrument now consists mainly of in-circuit emulators," says Wampeter. "But sales of in-circuit emulators are growing, spurred by additional software—CASE software coupled with software for embedded systems, as well as debuggers, compilers, and so on." In 1988, the development-system market grew 12% to $530 million. In 1989, it may swell more than 12% to $595 million.

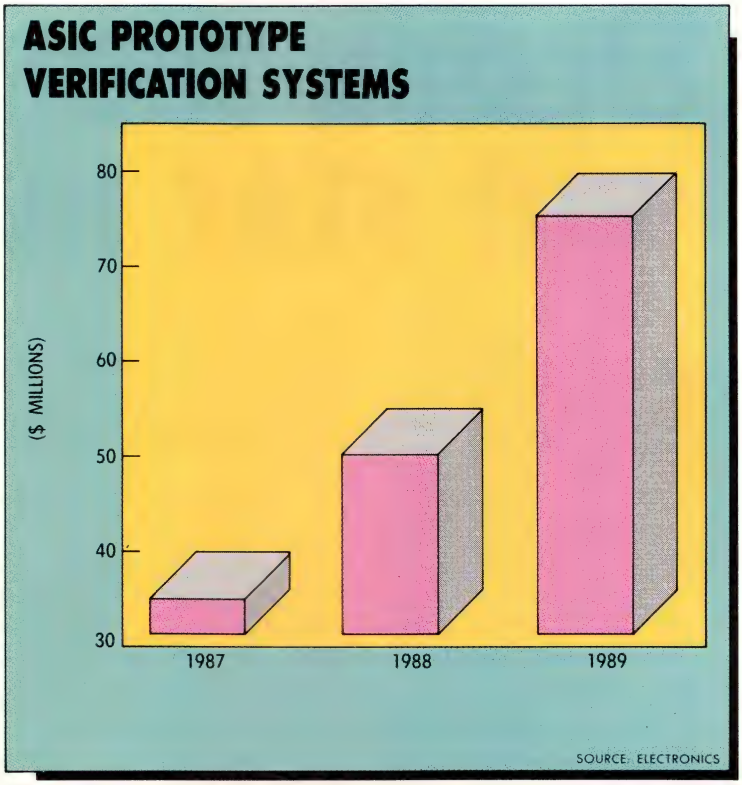
The whopping 50% growth projected in ASIC-prototype verification systems for 1989 is a result of the industry's massive move toward semicustom silicon. In 1988, the instrument category grew 43% to $50 million; in 1989, it is projected to hit $75 million. Makers of ASIC verifiers have been developing systems with higher data rates and pin counts, but now there is a strong trend toward lower-cost versions, according to Andreas Wilbs, product manager of IC test at HP in Böblingen, West Germany.

"ASIC verifier manufacturers are going to be bringing features found in high-end verifiers, such as tester-per-pin architecture, down into a lower-priced unit—around $50,000," agrees Norbert Laengrich, vice president of marketing and sales at HiLevel Technology in Irvine, Calif. These systems will serve customers building ASICs with under 200 pins.

Tektronix Inc. of Beaverton, Ore., has just introduced such a low-cost logic-verification system. "We have applied increased ASIC integration in building a product with high performance priced comparably to a work station," says Dick Knight, vice president of Tektronix's systems group. "It is now possible to have a verification system—the Tektronix LV500—for between $55,000 and $172,000." But Tektronix is not alone with such a product; HP has also fielded its HP82000 model D50.

Yet another type of ASIC-development tool should come onto the market this year to supplement ASIC verifiers. Offered by startup Quickturn Systems Inc. of Mountain View, Calif., the $125,000 product is a real-time in-circuit emulator for ASICs. It allows a design team to emulate its ASIC design in hardware before it is put into silicon. The designer passes his ASIC netlist to the emulation system, which then emulates the ASIC in the prototype system at up to 10 MHz.

A mature market such as test and measurement remains vital by having new products, such as ASIC verifiers and the new ASIC emulator, replace or supplement existing products. The next major growth opportunity will be modular instruments built to the VXI (VME extensions for instrumentation) specification. VXI will supplement and replace "rack-and-stack" systems built around the IEEE-488 instrumentation-bus standard. The industry is through the product development phase for VXI and plans to begin producing in 1989.


ASIC PROTOTYPE VERIFICATION SYSTEMS

SOURCE: ELECTRONICS

"In the last few months the product category has become real with a number of new product introductions, including ours," says Knight of Tektronix. In 1989, he expects early adopters to begin buying the products. But "VXI-bus products won't see large growth in sales until 1991, when there may be a broad range of products available," says Prime Data's Wampeter. ☐

TEST & MEASUREMENT EQUIPMENT

	(millions of dollars)		
	1987	1988	1989
Automatic test equipment, total	**1,850**	**2,275**	**2,515**
Active (discrete) component test systems	55	53	50
Automated field-service testers	65	75	80
IC testers, total	953	1,302	1,452
Benchtop testers	23	27	30
General-purpose systems	510	675	750
Specialized test systems (linear, memory, burn-in, etc.)	420	600	672
Interconnection and bare pc-board testers	185	203	220
Loaded pc-board testers, total	592	642	713
In-circuit	322	340	380
Functional	210	230	250
Combined	60	72	83
General test equipment, total	**3,561**	**3,828**	**4,130**
Amplifiers (laboratory)	20	23	28
Analog voltmeters, ammeters, and multimeters	30	31	32
Audio oscillators	31	33	34
Audio waveform analyzers & distortion meters	141	147	151
Calibrators and standards, active & passive	169	174	184
Dedicated IEEE-488 bus controllers	105	111	119
Digital multimeters, total	160	170	182
3-1/2 digit & below	95	105	115
4-1/2 digit & above	65	65	67
Electronic counters, total	146	138	130
Frequency (500-MHz and below)	28	26	24
Microwave (above 500 MHz)	46	44	41
Universal	72	68	65
Frequency synthesizers (below microwave frequencies)	83	82	101
Function generators	72	79	87
Pulse generators	27	28	29
Signal generators, total	327	343	346
Rf (under 2 GHz)	218	223	224
Microwave (over 2 GHz)	109	120	122
Logic analyzers	180	193	205
Microprocessor development systems	475	530	595
Modulation analyzers	11	12	13
Noise-measuring equipment	14	15	16
Oscilloscopes	500	540	580
Panel meters	110	115	120
Personal-computer-based instruments	45	55	75
Recorders & plotters	407	440	462
Rf/microwave network analyzers	55	60	65
Rf/microwave power measuring equipment	31	32	33
Spectrum analyzers	350	388	427
Temperature-measuring instruments	37	39	41
ASIC prototype verification systems	35	50	75
TEST & MEASUREMENT EQUIPMENT, TOTAL	**5,411**	**6,103**	**6,645**

All figures in current U.S. dollars.

CAD/CAE

DESIGN TOOLS SLOW BUT STAY HEALTHY

The market for computer-aided design and engineering tools for the electronics industry will not escape the economic slowdown that the rest of the U. S. electronics industry faces in 1989. But while its rate of growth will slow—to 27% in 1989 from 40% in 1988—sales will still rise faster than most other segments of the electronics industry, hitting $1.04 billion.

Growth rates will decline for both hardware platforms and software tools in this market (which does not include CAD and CAE tools for mechanical engineering, architecture, and other industries). The former will drop from a 49% growth rate in 1988 to a 26% growth rate this year; the latter, from 37% to 29%.

In hardware, the annual *Electronics* survey shows sales of personal-computer-based work stations will increase modestly, from $28 million last year to $31 million this year. That's growth of 11%—a negligible change from 1988's 12%. The slowdown in growth should be much more dramatic for 32-bit work stations, which could drop from a 55% growth rate to 27%. However, that 27% represents an increase in sales from $223 million last year to $284 million this year—almost 10 times the dollar value of PC-based sales.

Software is where the action is. The total market for CAD/CAE hardware is less than half that for CAD/CAE software—$251 million for hardware and $569 million for software in 1988. Roughly the same proportion will hold true this year, with total hardware sales growing to $315 million while total software sales climb to $727 million.

Front-end tools for design capture hold the lion's share of the market; their sales should reach $420 million this year, a 34% gain over 1988's $314 million. Growth is slowing only slightly; 1988 saw a 40% rise from 1987. But back-end tools for integrated-circuit design will account for only $125 million this year. That is 15.7% better than 1988, but the rate of growth is losing speed; in 1988 sales grew 33% over 1987.

Two other software categories, printed-circuit-board design and project-management tools, will grow, but again more slowly than they did in 1988. The former will reach $125 million in sales, an increase of 23% from 1988 and down from 1988's 29%. And the latter will reach $57 million in sales after climbing to $45 million last year.

Front-end software growth is being spurred by some new tools like logic synthesizers, the growth of which is astounding—*Electronics* projects sales will climb 100% this year. That's actually a drop from 1988, when sales soared 900%. The growth numbers are misleading, however: it's still a small market. Sales in 1989 will reach only $20 million.

More representative are logic simulators, mature products that have been continually enhanced. Along with fault and timing simulators, their sales should reach $226 million this year for healthy growth of 33%, only slightly less than 1988's 35% Also keeping up a respectable pace are schematic-capture tools. Their sales should climb to $158 million this year, a 33% rise over 1988 and a gentle decline from last year's 40% growth rate.

Back-end tools lack this mixture of explosive growth for new products and steady growth for older ones. The two largest-selling categories are design-rule checkers and floorplanners and place-and-route tools, both of which are mature products. Accordingly, *Electronics* predicts checkers will register only 7% growth this year, to $45 million. Floorplanners and place-and-route tools will grow by 13%, to $51 million.

Among back-end tools, layout editors will do best in 1989, climbing to $29 million from $21 million last year. That's a growth rate of 38%, compared with 24% for 1988—the only CAD/CAE tool, whether hardware or software, to grow more this year than last. ☐

CAD/CAE

(millions of dollars)

	1987	1988	1989
DESIGN WORK STATIONS, TOTAL	**169**	**251**	**315**
PC-based	25	28	31
32-bit microprocessor-based platforms	144	223	284
DESIGN SOFTWARE, TOTAL	**415**	**569**	**727**
Design capture, total	225	314	420
Schematic capture	85	119	158
Logic, fault, & timing simulators	126	170	226
Logic synthesizers	1	10	20
Model libraries	13	15	16
IC design software, total	81	108	125
Design-rule checkers	31	42	45
Floorplanners, place & route tools	33	45	51
Layout editors	17	21	29
Printed-circuit-board design	79	102	125
Project-management software	30	45	57
CAD/CAE, Total	**584**	**820**	**1,042**

All figures in current U.S. dollars.

CAMCORDERS, CDs RING UP BIG SALES

If slow but steady wins the race, then the U. S. consumer electronics market is on the right track. *Electronics* projects a third straight year of about 3% growth for the segment in 1989, to $24.8 billion.

The market will be buoyed this year, as it was last year, by continued strength in video camera/recorders (camcorders) and audio compact-disk players. Adding excitement this year is the expected emergence of a brand-new product category, "personal video" gear—tiny liquid-crystal-display TVs with miniaturized video-cassette recorders in the same handheld units.

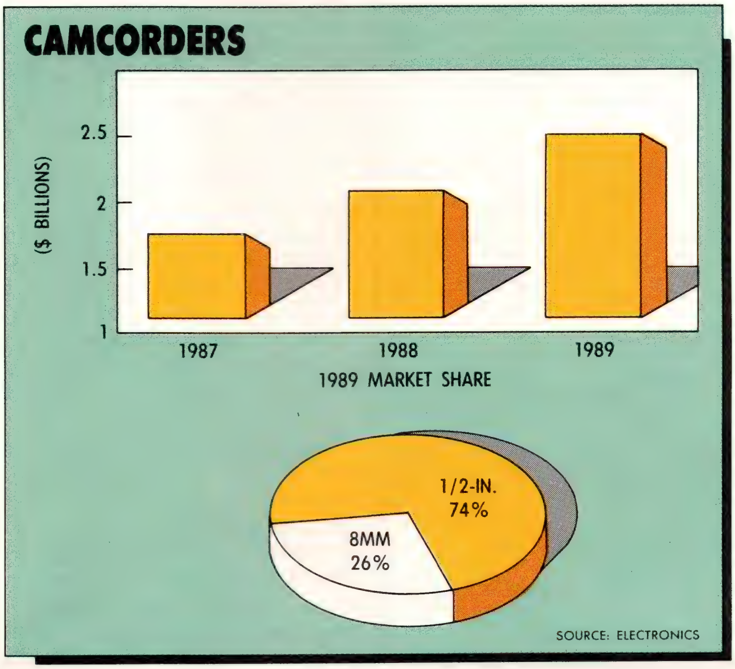
In general, though, the industry's 2.8% projected growth this year—rising from 1988's $24.1 billion sales mark—probably won't have consumer-equipment vendors dancing in the aisles. Both the video and audio sectors are expected to hold their own, at about 3% and 2% growth respectively this year. Video will rise from $12.7 billion last year to $13 billion; audio from a bit under $7 billion to a little over. The personal consumer products segment will slow to about 3%, off from 11% in 1988, with sales rising to $4.6 billion this year.

Among major product categories, *Electronics* projects the strongest 1989 growth in 8-mm video camcorders, which will soar by 48% to hit $603 million in sales. That's a drop from last year's 55% growth rate, but the 8-mm units will continue to snatch market share this year from camcorders based on the larger ½-in. VHS and compact VHS (VHS-C) formats.

Curiously, ½-in., full-size VHS accounted for about 65% of the U. S. market and VHS-C ½-in. models accounted for only 15%. In Japan, that ratio is reversed, with only 15% of the camcorder market in full-size VHS, says Robert Gerson, editorial director at the New York industry trade publication *Twice*. He, like others, expects that full-size VHS will begin losing ground in the U. S. in 1989, with its market share dropping to perhaps 50% of the total. *Electronics* projects 8-mm format will take 26% of the total $2.3 billion U. S. market, up from 20% in 1988. Growth rates in the two ½-in. formats will slow from last year's 13% growth, but will still register a healthy 8%, to $1.7 billion in 1989.

Camcorders will anchor growth in the $13.1 billion video segment in 1989, but bigger growth is also expected by home satellite-receiver makers this year. Though the category managed only a 1% increase in 1987, business climbed last year by a healthy 15%, to $414 million. *Electronics* projects an additional 30% growth in 1989, to $538 million.

Another category that may finally be primed for a comeback is video-disk players. The play-only medium lost out in its first try at the market to lower-priced, play/record VCRs. But vendors are hoping for resurgence on the strength of the compact-disk video (CD-V) format, unveiled by a group of about 30 vendors in mid-1987. CD-V combi-players, as they are called, will handle multiple disk formats—conventional 3-in. and 5-in. audio CDs, 8-in. and 12-in. video disks, as well as the 5-in. CD-V format that combines five minutes of digital video and sound with 20 additional minutes of sound only. *Electronics* projects 44% growth for the catego-



SOURCE: ELECTRONICS

ry this year, to $65 million.

But the flashiest star in the video universe this year is likely to be personal video. At Sony Corp., which introduced its GV-8 Video Walkman last June, R. Jay Sato is optimistic about the new category. "Like the audio Walkman, which has sold millions of units, we think the same concepts will apply," says Sato, who is national sales manager, 8-mm, for Sony Corp. of America in Park Ridge, N. J.

The video segment needs new high-growth products like personal video, video-disk players, and camcorders. The bread-and-butter high-growth category through the mid-1980s—the VCR—will show a third straight year of decline in 1989. And while color TV will continue to anchor the video segment, accounting for more than half of all 1989 video sales, the TV market will flatten out this year.

CONSUMER EQUIPMENT

(millions of dollars)	1987	1988	1989
Audio equipment, total	**6,797**	**6,943**	**7,075**
Car	2,700	2,730	2,760
Stereo equipment, total	1,771	1,823	1,845
Compact systems	371	358	345
Components	1,400	1,465	1,500
Radios	445	425	425
Compact-disk players (home)	450	530	630
Portable audio (includes CDs)	1,431	1,425	1,400
Digital-audio-tape players	0	10	15
Video equipment, total	**12,572**	**12,698**	**13,108**
TV receivers, total	6,545	6,700	6,745
Color	6,260	6,440	6,500
Monochrome	285	260	245
Projection-TV receivers	527	499	502
Video-cassette players and recorders	3,440	3,040	2,920
Camcorders, total	1,668	2,000	2,323
8-mm	264	408	603
1/2-in.	1,404	1,592	1,720
TV/VCR combinations	0	0	15
Video-disk players	32	45	65
Home satellite-receiving stations	360	414	538
Personal products, total	**4,045**	**4,493**	**4,632**
Calculators	495	517	537
Musical instruments	513	528	543
Microwave ovens	1,895	1,583	1,399
Telephone-answering devices	400	457	505
Video games (including software)	742	1,408	1,648
CONSUMER ELECTRONICS, TOTAL	**23,414**	**24,133**	**24,815**

All figures in current U.S. dollars.

With VCRs now estimated to be in 56% of all U. S. households, the industry is counting on replacement-unit and second-unit purchases for a bigger chunk of VCR sales. Sales took a nose dive in 1988, falling by 12% to $3 billion in 1988. This year's decline looks less severe. *Electronics* projects VCR sales to drop by 4% more, to $2.9 billion.

Color TV sales—despite a high household penetration level, estimated at 94% by the Electronics Industries Association—have held up remarkably well. The category grew by 2% in 1988, to $6.4 billion. *Electronics* projects less than 1% growth in color TVs this year, however, to $6.5 billion.

The key to the color TV market's long life includes a stronger replacement and second-unit business than in VCRs. And the move toward stereo TV, bigger screens, and improved definition TV (IDTV) are also contributing. The shift to larger 27-, 31-, and 32-in. screen sizes is expected to gather force in 1989.

That trend could continue to put pressure on vendors of projection TV, who saw sales drop by 5% in 1988, to $499 million. *Electronics* projects slight growth this year, 0.6%, to $502 million.

Meanwhile, in the audio segment, compact disks will continue to carry the day. Sales of home CD players are projected to show strong 19% growth to $630 million this year, on top of 18% growth in 1988, when sales rose to $530 million.

At least one observer—Mark Finer, director of Communication Research Inc., a Pittsburgh consulting firm—thinks the growth will extend to automobile CD players. If so, however, it won't boost the total car audio category this year. *Electronics* projects car audio sales to edge upward by 1% to $2.76 billion.

Audio vendors note, however, that strong CD sales in 1989 will continue to pull through higher sales of audio components, such as speakers, which CD owners are buying to upgrade their systems. But the bloom on that rose may be starting to fade, since many CD owners have already made the conversion to better components. *Electronics* projects 2% growth in audio components this year to $1.5 billion, down from last year's 5% growth rate.

While the play-only CD medium is still thriving, the U. S. market for play-and-record consumer digital-audio-tape players has still failed to materialize. Consumer DAT units made their first U. S. appearance at the January Winter Consumer Electronics Show three years ago. And sales of play/record consumer DAT units are already well under way in Japan. But emergence of the technology here has been stymied by opposition by the record industry, which fears that DAT's ability to produce very high-quality recordings could lead to widespread unauthorized copying of prerecorded materials.

U. S. DAT sales so far have been limited to professional units, a few play-only car units, and a small volume of gray-market sales to audiophiles. *Electronics* estimates the size of the consumer DAT gray market at $10 million last year, rising to $15 million this year.

In the personal consumer products segment, video games may be this year's most closely watched category. Video-game hardware and software vendors are coming off two years of booming growth, with 1988 sales of $1.4 billion topping those of $742 million in 1987 by 90%.

The U. S. market leader, Nintendo of America Inc., is predicting more robust growth in the video-games category again this year—nearly 50%. Others, however, are more cautious, remembering the early and mid 1980s, when skyrocketing sales were followed by a bust that all but erased the industry. *Electronics* is projecting that U. S. factory sales of video-game hardware and software will indeed continue to grow, but much more slowly—by 17% in 1989, to $1.6 billion.

Strong sales of telephone answering devices are also expected to help boost the personal consumer products segment in 1989. *Electronics* projects their sales will grow by a healthy 11% in 1989, to $505 million. ☐

Circle 84 on reader service card →

AN AMPLE 7% HIKE IS IN THE CARDS

The industrial electronic equipment sector showed surprising strength in 1988, growing at a relatively hearty 9% rate that eclipsed many vendors' expectations. *Electronics* projects continued growth in 1989, when U. S. sales of industrial gear will rise by 7%, to $6.3 billion. Although growth this year won't match the pace of 1988, it will mark a third straight year of expansion and therefore of recovery from 1986, when sharp cutbacks in spending by the auto industry caused sales to drop by 5%.

Strong performance in a number of areas pushed 1988 growth above the 6% *Electronics* projected a year ago. The largest category—process-control equipment, which makes up 60% of all industrial electronics equipment—grew 10%, thanks to the food-processing industry, which began turning to automation last year. Vision, inspection, and numerical-control systems also outran projections.

This year's outlook calls for more of the same. Sales to the food industry will keep growing. Other process industries, including paper, chemicals, and pharmaceuticals, should have healthy years, which will translate into more equipment sales. And even the automotive industry should account for a fair number of sales—not by the big automakers themselves, but by their suppliers, who are increasingly turning to automation as a way to meet higher standards for quality and in order to meet tight, just-in-time delivery schedules.

There are some clouds on the horizon. One is the possibility of a general economic downturn in the second half of 1989. Another is merger mania. The recent flood of highly leveraged buyouts and large corporate acquisitions could delay or squash automation spending plans at some companies.

Nevertheless, the general outlook appears to be one of cautious optimism for the year. One reason is the steady growth expected for the largest segment of the market, process-control equipment. *Electronics* projects sales will reach $3.8 billion this year, an increase of 7%—less growth than 1988's 10% rate, but still respectable.

INDUSTRIAL EQUIPMENT

(millions of dollars)	1987	1988	1989
Energy-management equipment	490	505	520
Inspection systems	310	338	375
Motor controls (speed, torque)	630	660	691
Numerical-control systems	255	274	290
Process-control equipment, total	3,203	3,528	3,784
Data-acquisition systems	265	304	329
Process instrumentation	2,363	2,592	2,773
Programmable controllers	575	632	682
Robot systems	402	414	431
Vision systems	130	180	200
INDUSTRIAL EQUIPMENT, TOTAL	**5,420**	**5,899**	**6,291**

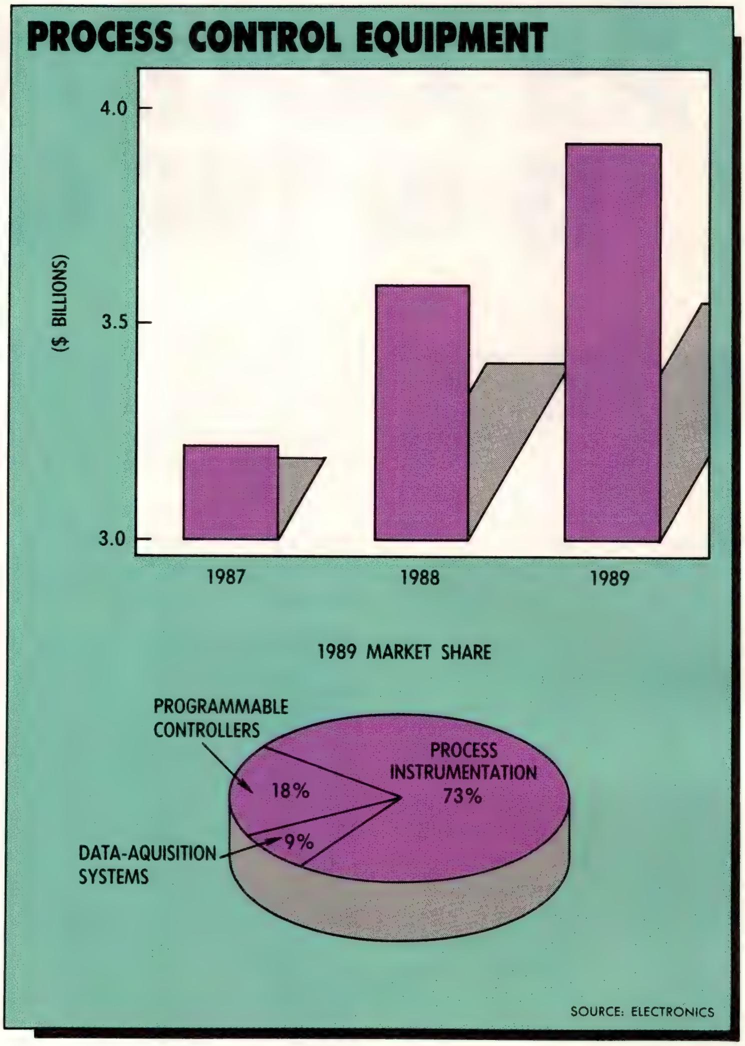
All figures in current U.S. dollars

The process-control market is dominated by process instrumentation, and not surprisingly the projections for instrumentation correspond closely to those for process control. Last year's 10% growth will give way to 7% growth this year, for a healthy $2.77 billion in sales. Fueling the growth will be increased concerns about quality in manufacturing, for which instrumentation is crucial, says Roger W. Ford, manager of long-range product planning at The Foxboro Co. in Foxboro, Mass. "You'll find that to do what you want to do, you've got to take more measurements in from the process," he says.

Also boding well is the relative health of the chemical, paper, and pharmaceutical industries, says David Penning, director of manufacturing automation services at Dataquest Inc., the San Jose, Calif., market research firm. "There's even some rebounding in the primary metals market," and in other raw-goods categories such as lumber, he adds. "But the food industry is the one that everyone is talking about. There are lots of little food processors that are becoming fairly automated. And it's a huge industry."

As with process instrumentation, *Electronics* projects sturdy but slower market growth rates this year in the other two process-control equipment subcategories. The market for data-acquisition systems will grow by 8% to $329 million in 1989, down from last year's 15% spurt. Sales of programmable controllers, meanwhile, will hit $682 million to reach an 8% growth rate in 1989, according to *Electronics*' projections. That's two points off last year's pace.

Process control may be the largest industrial electronics market, but the fastest growth is elsewhere. *Electronics* predicts the growth rate for vision systems will top the list, at a little more than 11%, with sales rising to $200 million. That's strong growth, but something of a let-



SOURCE: ELECTRONICS

down after last year's 39% pace. Growing almost as fast, at just under 11%, are inspection systems, and their growth is actually speeding up—in 1988, sales climbed 9% over 1987. Sales this year may total $375 million.

Spurring sales in both vision and inspection systems is the drive in industry for quality, as U. S. manufacturers strive to retain or regain global competitiveness. In inspection systems, "the big investment is primarily in the auto industry, but not by the Big Three themselves," says Dataquest's Penning. "The automakers are shoving their inspection requirements back down to their suppliers, and they are forming partnerships with their key suppliers."

The trend is spreading to other industries too, Penning notes, including aerospace, fabricated and metal products, and electronics. "Manufacturers are finding out they also get higher quality and lower cost," he adds.

The only other category besides inspection systems that is expected to show better growth this year than in 1988 is robot systems. However, at 4%, to $431 million in sales, it's not exactly breathtaking growth. Robot vendors were hit the hardest when automakers jerked the rug out from under the big spending plans they'd made, so they missed out on last year's market bonanza, too. They grew by a scant 3%.

Industry observers say that's about what robot vendors can expect for the next few years. "We're forecasting that it will take until the 1992-1993 timeframe for robots to even get back to 1986 sales levels, which were around $600 million," says John D. Meyer, president of Tech Tran Consultants Inc., a consulting firm in Lake Geneva, Wis.

In the meantime, robot makers are struggling to break out of their reliance on the automotive industry. Robots are moving into appliances, pharmaceuticals, and electronics applications, among other industries.

In other industrial categories, numerical-control system sales will slow from last year's 8% growth rate to 6% in 1989, when sales will total $290 million. In motor controls, *Electronics* projects 4.7% growth this year, to $691 million, in line with last year's 4.8% growth rate. Likewise, steady growth is seen in energy-management equipment at about 3% with 1989 sales coming in at $520 million.

All in all, the mood among factory-gear vendors and market watchers alike is cautiously upbeat for 1989, even among those who foresee a recession. "The first half of this year will be pretty good, then trailing off in the second half," says Dataquest's Penning. But the recession will be mild, he predicts, with factory-automation sales turning back up again by the second half of the 1990s.

But there is one other fly in the ointment. "All this merger stuff is really affecting the market," warns Lucia Quinn, vice president of Harbor Research Corp., a Boston market research firm. "All these businesses being consolidated is slowing down the process of evaluating what's going on in a plant, and how much money needs to be invested. And people once again wind up putting off those investments, and it puts them further and further behind." What's more, Quinn adds, a leveraged buyout can saddle a company with a mountain of debt, leaving little money to spend on automation.

Penning agrees, saying "1988 was a banner year for factory automation, and I think that will carry through. But the U. S. needs to quit all this merger flimflam and get on with it." ☐

UNDER THE GUN AT THE PENTAGON

George Bush made a campaign promise: funds needed to close the burgeoning U. S. budget deficit would not come out of defense outlays. But when Bush takes office on January 20, he won't really have any choice but to cut defense spending. And almost everyone in the defense industry knew it all along.

In fact, pressure to get control of the mounting federal debt will squeeze defense spending for years to come. Some observers think the decline will only last a couple of years, but the Electronic Industries Association predicts that, in constant 1988 dollars, defense spending will decline by up to 2% a year through 1994, then level off for the rest of the century, growing at less than 0.5% a year.

This year, the Pentagon is expected to trim its spending for electronics by just over 2%, laying out $46.8 billion. That compares with $47.9 billion in 1988, the EIA's Government Division says. The cutback is the fourth in a row; last year's was 4%.

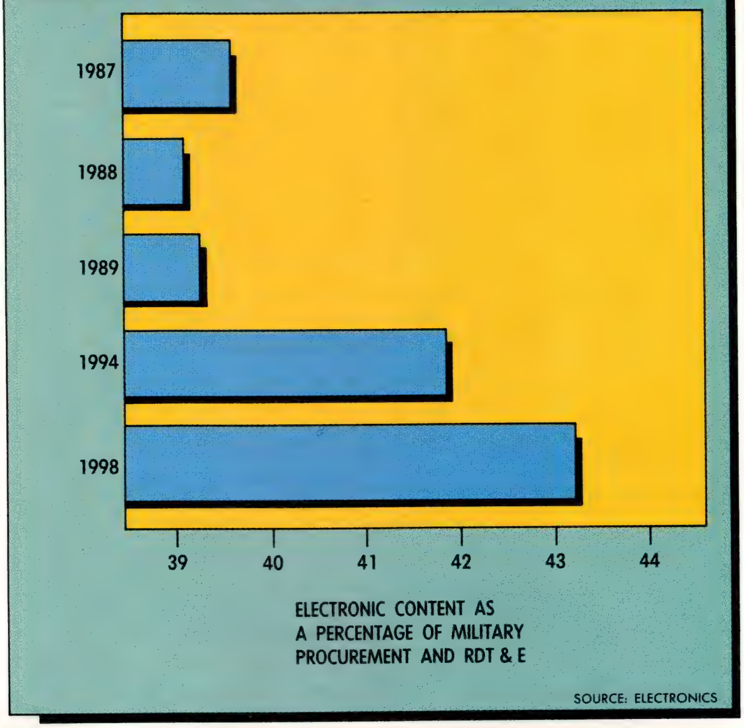
The nondefense side of the federal government will get caught, too. The federal Office of Management and Budget says purchases of data-processing and telecommunications equipment will be held down for virtually all nonmilitary federal agencies. A notable exception is the National Aeronautics and Space Administration. NASA will spend $1.26 billion on information technology in 1989, up 15% from 1988 and almost 35% from 1987, the OMB says. The Department of the Treasury will spend more on information technology than any agency outside the Pentagon, but growth there is leveling off. After a 30% jump to $1.22 billion in 1988, Treasury spending will grow only 5% in 1989, to $1.29 billion, the OMB says.

The Department of Defense, however, will feel the budget squeeze most of all. Spending in 1989 will decline in almost every major category. Among the few bright spots are military space applications. Spending will rise there from $5.6 billion in 1988 to $5.9 billion in 1989, a 5% growth spurt.

Electronics executives can take some solace in the fact that while the defense pie is shrinking, their portion continues to get larger year by year. Overall military spending will drop 9.3% from 1987 to 1990, for example, but spending for electronics will be down only 8.2%, based on the EIA's 10-year defense-budget forecast. The electronics content will actually rise over the next decade, from about 37% of the overall defense budget in 1986 to almost 42% in 1994 and more than 43% by 1998. But the growth in overall content is not keeping pace with the rate of overall decline.

Budget constraints are not the only factor in defense spending, of course, as Byron Callan, an analyst with Prudential-Bache Securities in New York, points out. Relations with the Soviet Union could deteriorate and spur greater spending. But assuming a stable international situation,

MILITARY ELECTRONIC CONTENT



SOURCE: ELECTRONICS

the key issue for at least the next two years will be the budget deficit. Callan expects spending will hold steady at the nominal 1988 level of $295.8 billion, while inflation continues to steam along at around 4%.

That doesn't mean there isn't plenty of opportunity for the right companies. Chip makers should do very well, particularly in the area of digital-signal processing, says Philip Seidenberg, an analyst with market researcher Frost & Sullivan in New York. Training and simulation systems—which are major consumers of chips—continue to be one of the hottest growth markets to come along in years, and antisubmarine warfare, radar, electronic warfare and countermeasures, and the "black" programs in intelligence and surveillance are also ripe for growth.

But aircraft, the glamour market in military technology, will not present much in the way of opportunity in the next several years. Overall aircraft spending declined 12% from 1987 to 1988 and will come down another 5% in 1989. Spending will total $10.2 billion this year, the EIA projects. That trend isn't likely to change any time soon, since much of the remaining money will be wrapped up in high-priced, maturing programs, says J. Edward Waesche, director of strategic and market planning at Grumman Corp. in Bethpage, N. Y., and chairman of EIA's 10-year-forecast committee.

MILITARY EQUIPMENT

	(millions of dollars) 1987	1988	1989
Aircraft, total	12,100	10,700	10,200
Procurement	10,400	8,800	8,200
R&D, testing, evaluation	1,700	1,900	2,000
Electronics and communications, total	10,400	9,800	9,500
Procurement	6,900	6,400	6,400
R&D, testing, evaluation	3,500	3,400	3,100
Missiles, total	7,500	7,400	7,200
Procurement	5,000	5,200	5,300
R&D, testing, evaluation	2,500	2,200	1,900
Ordnance & weapons, total	1,200	1,100	1,100
Procurement	1,000	1,000	1,000
R&D, testing, evaluation	200	100	100
Ships, total	5,100	5,700	4,300
Procurement	4,300	5,000	3,600
R&D, testing, evaluation	800	700	700
Space, total	6,000	5,600	5,900
Procurement	2,600	2,500	2,700
R&D, testing, evaluation	3,400	3,100	3,200
Vehicles, total	800	800	1,600
Procurement	800	700	800
R&D, testing, evaluation	0	100	800
Other, total	6,600	6,800	7,000
Procurement	2,400	2,400	2,500
R&D, testing, evaluation	4,200	4,400	4,500
MILITARY EQUIPMENT TOTAL	**49,700**	**47,900**	**46,800**

Source: EIA Government Division

Figures, in current U.S. dollars, represent only the value of electronic content in military equipment

On the other hand, space electronics funding, which suffered slightly in the past two years, now offers one of the brightest outlooks. Electronics revenues in this sector should total $5.9 billion, marking the start of a slow but steady growth path that the EIA expects will continue for the next decade. The impetus is growth in satellite communications and intelligence coupled with continued heavy R&D spending on command, control, and communications systems and the Strategic Defense Initiative.

In general, however, managers will have to refocus the strategies that carried many military suppliers through the 1980s—the notion that winning one big contract was better than winning several smaller ones. The fact is, there are no large-scale development programs on the order of the Advanced Tactical Fighter or B-2 bomber coming down the pike. Prime contractors who didn't win significant pieces of those programs will have to wait out the thin times, perhaps looking to new markets. "When you're under budget pressures, inevitably you have to look at ways of doing business that aren't so glamorous," says Grumman's Waesche. That means going after many smaller contracts instead of looking for and landing that one big airframe deal that can carry a company for a few years, he says. He suggests that many smaller opportunities exist in areas that are electronics-rich such as remotely piloted vehicles, battle-management systems, and command-and-control systems.

FEDERAL EQUIPMENT

	(millions of dollars) 1987	1988	1989
Hardware purchases	2,927	2,669	2,714
Hardware leases/rentals*	897	845	879
Commercial software and other equipment	330	333	343
Analysis & programming (custom software)	1,982	2,119	2,199
Consulting & studies	424	559	764
Systems design & engineering	171	262	264
Operations & maintenance	2,236	2,545	2,827
Other services & operating costs**	3,399	3,224	3,136
FEDERAL EQUIPMENT, TOTAL	**12,366**	**12,556**	**13,126**

Source: U.S. Office of Management and Budget

Figures, in current U.S. dollars, represent U.S. civilian and military purchases of data processing and telecommunications equipment and software

*Includes some operating costs that can't be broken out

**Includes time sharing, leased telecom services and lines, etc.

Meanwhile, in the nondefense sectors, government agencies are cutting back on new purchases wherever possible. Total federal spending for new computer and communications hardware dropped by $258 million from 1987 to 1988, a decrease of 9% to $2.669 billion, according to the OMB, which tracks federal purchases. And while the 1989 figure is now expected to inch back up to $2.714 billion, that's still 7% below the 1987 level. Leased hardware follows a similar pattern, falling 6% to $845 million in 1988 and rebounding to $879 million in 1989—still about $18 million less than in 1987.

The bright spot in nonweapon purchases is software. Purchases of commercial software rose slightly in 1988, from $330 million to $333 million, and should reach $343 million in 1989. However, that figure is distorted because it includes an unknown percentage of minor hardware purchases, says Ed Springer, an OMB analyst. But spending for custom software topped $2 billion for the first time in 1988, rising $137 million to $2.119 billion. Springer says that figure should jump another 4% in 1989 to almost $2.2 billion. ☐

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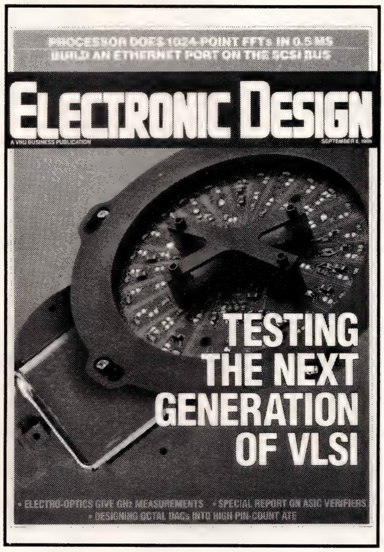
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SUPERCHARGED GROWTH WILL STALL

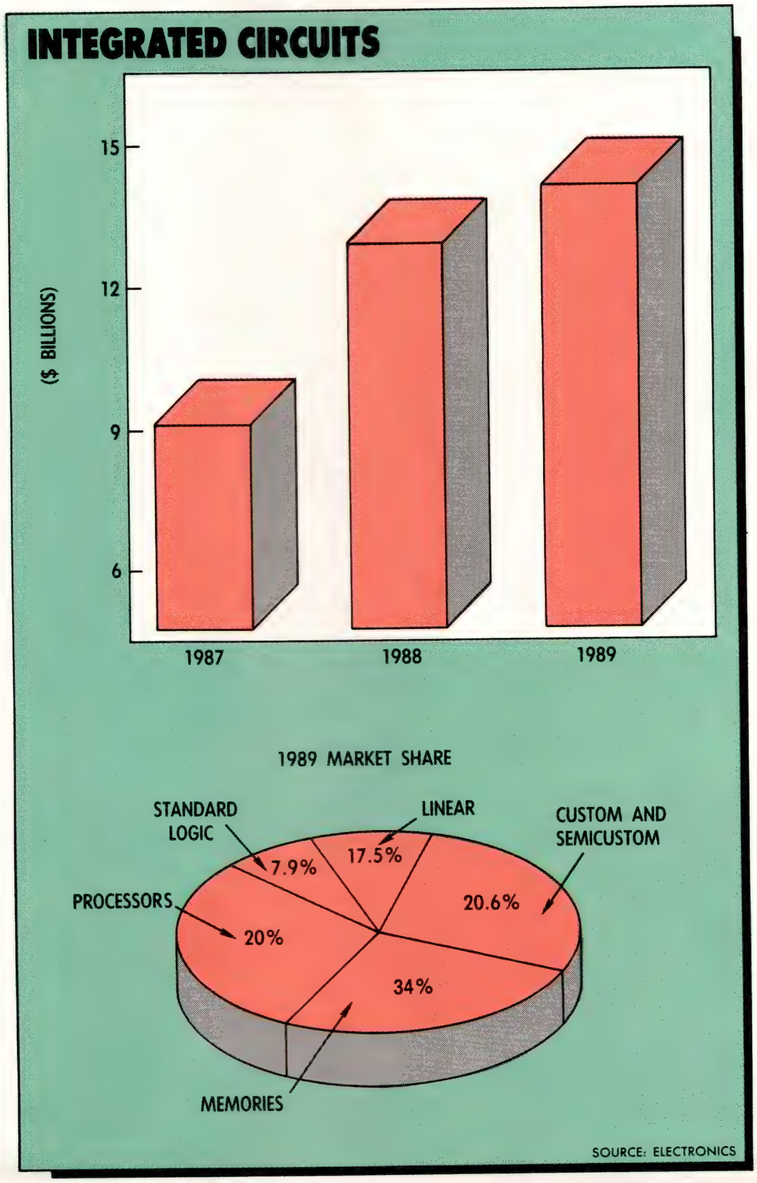
If the semiconductor industry roared ahead like a Grand Prix racer in 1988, 1989 will be the year it sputters like an old heap to much slower growth rates. Last year's heady 32% growth will slow to more modest rates—flat in some sectors, moderately brisk in others, and negative in a few more.

The *Electronics* survey indicates that total U. S. semiconductor sales during 1989 will grow only 9% overall, from $15 billion in 1988 to $16.4 billion. Integrated circuit sales should rise to $13.9 billion, up only 10% over 1988's $12.6 billion and a far cry from the 36% rise achieved last year. Discrete semiconductor sales should be even more modest: $2.14 billion in 1989, only 1% over 1988's $2.11 billion. Last year's rise was 16%.

In IC product categories, memories will rise only 10% to $4.6 billion, against a whopping 72% climb last year. Microprocessors and microcomputers will climb 16% to $2.7 billion following a 42% rise in 1988. Standard logic will actually decline by 1.5%, dipping to $1.05 billion after a 3% gain last year.

"We are seeing some short-term softening in the market due to pessimism about the overall economy," says Dwain Aidala, vice president of marketing at Mitsubishi Electronics America Inc. in Sunnyvale, Calif. Such fears may or may not be real, says Larry Jordan, vice president of marketing at Integrated Device Technology Inc. in Santa Clara, Calif. Whether they are or not, he says, the result is that during the first part of 1989, original-equipment manufacturers and end users are being somewhat more conservative in their semiconductor orders. Also, many in the industry are worrying about how much gas is left in the tank of the engine that has been driving much of its growth: the personal computer.

Also contributing to the overall slowdown is the roller-coaster ride of random-access memories. Last year, higher prices for these devices, which were in critically



SOURCE: ELECTRONICS

short supply, had an exaggerated impact on increasing dollar sales. This year the opposite is true. A projected surplus and lower prices mean decreasing dollar sales in 1989.

The *Electronics* survey shows that by far the greatest change in market direction is occurring in memory sales. Last year marked a 72% rise for all memories over 1987, from $2.45 billion to $4.2 billion. This pace will slow drastically in 1989, for a meager 10% growth rate to $4.6 billion.

The wide swings in the dynamic RAM market are the main cause. *Electronics* predicts DRAM sales will rise only 12.5% to $2.65 billion, compared with 1988's dizzying 130% climb to $2.35 billion. But these numbers are skewed, says N. D. Reddy, president of Alliance Semiconductor Corp. in San Jose, Calif. Last year, when DRAM manufacturers were converting fabrication lines from 256-Kbit to 1-Mbit chips, shortages of both occurred, and prices skyrocketed. With up to eight 1-Mbit fabs coming on line in 1989, the average DRAM selling price will dive as undersupply becomes oversupply. The only question is when.

Although unit volume is expected to increase during 1989, 1-Mbit DRAMs should lose some of their sales momentum as prices drop. *Electronics* expects a 62% increase to $1.97 billion, compared with the 408% increase to $1.22 billion in 1988. Beefing up sales figures will be the first generation of 4-Mbit parts with their much higher prices, which are expected to generate at least $110 million in sales this year.

As the 1-Mbit circuits become available in high volumes, sales of smaller-density parts will rapidly decline. Sales of 64-Kbit parts are expected to plummet 44%, from $90 million to $50 million. Sales of 256-Kbit DRAM parts, instead of climbing by 49% to $1.04 billion, as in 1988, will drop by 50%, to $520 million.

Much the same thing will happen to static RAMs. Last year's 36% growth rate will decline to 4%, to $679 million. Most of the deceleration will be in slower, 125- to 200-ns SRAMs, says IDT's Jordan. By contrast, the higher-speed, sub-25-ns parts are expected to grow by at least 10% to 15% during 1989, he says.

A similar downturn is afflicting nonvolatile electrically erasable memories, says Dale Prull, director of marketing at Wafer

SEMICONDUCTORS

(millions of dollars)	1987	1988	1989
Discrete, total	**1,822**	**2,113**	**2,142**
Diodes, total	771	882	870
Arrays (including bridges)	26	27	28
Rectifiers, total	550	645	631
Low-power (less than 25 A)	482	564	550
High-power	68	81	81
Signal	80	86	86
Special-purpose, total	115	124	125
Microwave (above 1 GHz)	19	20	21
Varactor	10	12	12
Zener	86	92	92
Protection devices	60	66	67
Thyristors	117	136	131
Transistors, total	874	1,029	1,074
Bipolar, total	624	711	713
Power (1 W or more)	332	380	382
Rf & microwave power	75	79	73
Small-signal	217	252	258
Field-effect, total	180	233	271
Power, total	130	175	210
High-power (above 20 W)	28	43	52
Power (to 20 W)	102	132	158
Small-signal	50	58	61
Gallium arsenide	70	85	90
Integrated circuits, total	**9,252**	**12,599**	**13,853**
Custom & semicustom ICs, total	2,010	2,565	2,735
Custom, total	1,010	1,275	1,330
Standard-cell	310	465	510
Other (including handcrafted)	700	810	820
Gate arrays	700	900	980
Programmable logic devices, total	300	390	425
Electrically reprogrammable	46	101	110
Fuse-programmable	254	289	315
Linear ICs, total	1,870	2,077	2,333
Amplifiers, operational	212	225	235
Amplifiers, instrumentation	80	89	100
Analog switches	128	137	160
Communications (codecs, etc.)	156	175	220
Consumer-product ICs	250	265	292
Data conversion, total	241	268	305
A-d converters	100	110	125
D-a converters	85	93	110
Multiplexers	26	27	31
Sample & hold	30	38	39
Interface	268	289	314
Voltage references and regulators	135	149	157
Power ICs	400	480	550
Memories, total	2,451	4,216	4,639
Magnetic-bubble devices	19	20	22
Random-access memory, total	1,505	3,009	3,329
Dynamic RAM, total	1,025	2,355	2,650
64-K or smaller	85	90	50
256-K	700	1,045	520
1-Mb	240	1,220	1,970
4-Mb	0	0	110
Static RAM, total	480	654	679
Bipolar	127	132	136
CMOS & MOS	353	522	543
Read-only memory, total	927	1,187	1,288
Bipolar, total	141	129	117
Fuse-programmable (PROMs)	57	52	47
Mask-programmable (ROMs)	84	77	70
CMOS & MOS mask-programmable, total	147	198	206
Electrically erasable, total	169	226	265
EEPROMs	130	172	205
Shadow (NVRAMs)	39	54	60
EPROMs (ultraviolet-erasable)	470	634	700
Microprocessors and microcomputers, total	1,611	2,293	2,662
Bipolar, total	259	248	252
LSI peripheral chips	143	134	136
Processors	116	114	116
CMOS and MOS, total	1,352	2,045	2,410
LSI peripheral chips, total	522	795	1,000
Controllers (disk-drive, CRT, etc.)	222	338	425
Other peripherals	300	457	575
Microprocessors, total	360	700	845
8-bit	110	214	259
16-bit	160	311	375
32-bit	90	175	211
One-chip microcomputers and microcontrollers, total	470	550	565
4-bit	59	84	94
8-bit	350	380	375
16-bit	61	86	96
Special-purpose processors, total	275	385	437
Digital-signal processors	50	100	120
Floating-point processors	90	125	150
Multipliers	100	120	125
Other	35	40	42
Standard logic families, total	1,035	1,063	1,047
BiCMOS	2	5	15
CMOS	221	272	275
Advanced (ACL, FACT)	7	16	27
High-speed (HCMOS)	95	104	103
Standard	119	153	145
ECL	75	75	72
TTL, total	737	711	685
High-speed (AS, ALS, FAST, etc.)	232	258	273
Low-power (LS)	415	386	362
Standard (S)	90	67	50
Optoelectronic devices, total	**332**	**361**	**377**
Imaging arrays	56	58	64
Laser diodes	5	6	7
Light-emitting diodes (discrete), total	172	198	206
Ir, near-ir	22	28	31
Visible	150	170	175
Optically coupled isolators	32	37	41
Photoconductive cells (light-dependent resistors)	5	5	5
Photodiodes	18	18	17
Phototransistors	33	30	29
Photovoltaic cells	11	9	8
SEMICONDUCTORS, TOTAL	**11,406**	**15,073**	**16,372**

All figures in current U.S. dollars.

Scale Integration Inc. in Fremont, Calif. Overall sales in 1989 are expected to rise 17% to $265 million. That's exactly half of 1988's growth rate, when sales hit $226 million. Much of the softness in EEPROMs comes from price attrition in lower-speed 120- to 150-ns versions—a trend that is ameliorated by the higher average selling prices in the higher-speed arena: sub-35 ns in 64 Kbits and smaller, sub-55 ns at the 128- and 256-Kbit level, and sub-100 ns at 1 Mbit and above.

The emergence of high-speed parts that are also very dense could spell the doom of such traditional nonvolatile memories as mask-programmable CMOS and bipolar ROMs as well as fusible-link bipolar PROMs. The *Electronics* survey indicates that sales in all three areas will continue to slip, down 9% in both 1988 and 1989.

The single brightest spot in the IC sector is microprocessors. *Electronics* projects 21% growth in the sector, to $845 million in 1989. That's a comedown from last year's 94% rise to $700 million, but a solid enough performance nonetheless. Moreover, the performance is broadly based across product lines. From 8 to 32 bits, there are 20% to 21% increases in sales forecast.

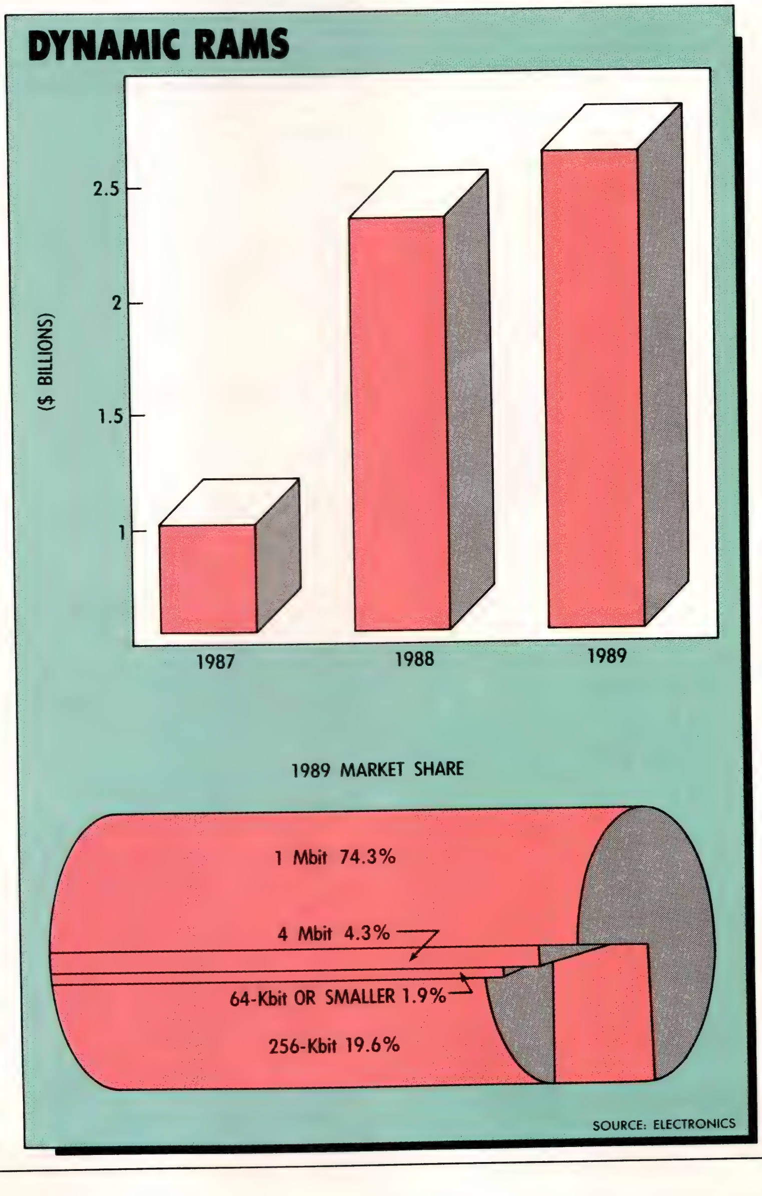
Buoyed by their use in embedded-control applications, 8-bit CPUs are expected to increase from $214 million in 1988 to $259 million in 1989. Sales of 16-bit parts should grow from $311 million to $375 million. Sales of 32-bit parts are expected to increase from $175 million to $211 million.

No one knows how long the boom will last, though. It depends on PC and peripherals sales. Recent announcements by Intel Corp. and Advanced Micro Devices Inc. are not encouraging. Intel, which makes the 16-bit 8086/80286 and the 32-bit 80386, reports that fourth-quarter revenue in 1988 will dip about 10% below the third quarter's; AMD reports that sales of its version of the 80286 were hit badly during the fourth quarter. "The question in the mind of everyone serving the PC market," says IDT's Jordan, "is whether this is due to a waning demand from personal computer users or if it is just a momentary oversupply." A number of factors indicate that the answer is that deman is lessening, he says.

First, PCs are selling to the same consumers who have always bought them for word processing, spreadsheets, and financial calculations. "There are some indications that the need for higher performance has been satisfied with the current generation of CPUs," Jordan says. Alternatively, users may be confused by the variety of competing offerings: Apple Macintoshes vs. IBM-compatible PCs, 286- vs. 386-based machines, and so on. Whatever the reason, Jordan says, the industry may have to adjust to downward to flat or even negative growth.

The microcontroller and bipolar-microprocessor market is already weakening. Microcontroller sales in 1989 will increase only 3% to $565 million. Four- and 16-bit controller sales are expected to grow about 12% each, but 8-bit sales—squeezed by low 4-bit prices and high 16-bit performance—will decline by 2%, from $380 million to $375 million.

For bipolar processors and peripherals, the news is modestly positive. The *Electronics* survey found that after dropping 4% to $248 million in 1988, sales will



SOURCE: ELECTRONICS

rise 2% in 1989 to $252 million.

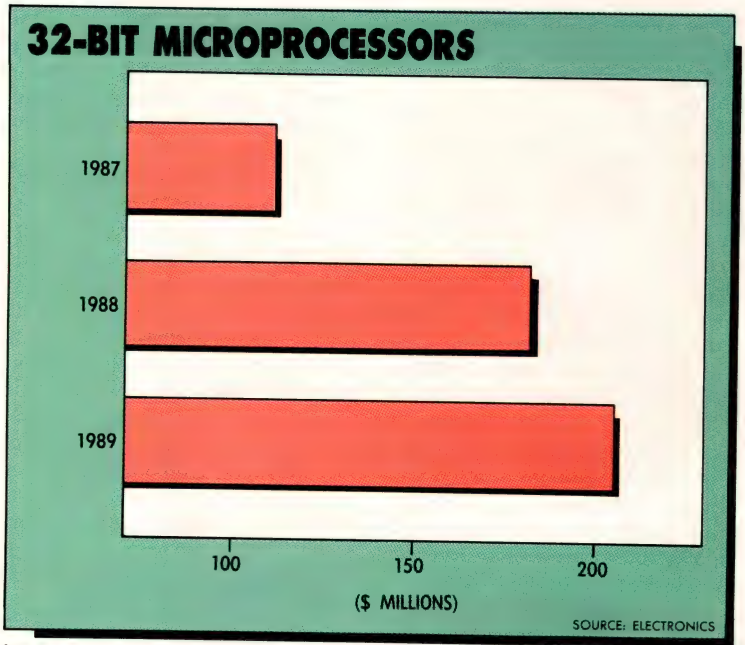
Thanks to their increasing use in the military and industrial markets, special-purpose processors are keeping their heads above water. *Electronics* projects that this segment—which includes digital-signal processors, floating-point processors, and multipliers—should grow 14% in 1989 to $437 million, following 40% growth last year. DSPs and floating-point units will carry the segment, rising by 20% each to $120 million and $150 million, respectively. Multipliers and various other special-purpose peripherals will increase only 4% and 5%, respectively.

Indicative of the widespread pessimism in the semiconductor market is the overall pattern of growth in custom and semicustom ICs. In previous years, they usually outperformed ICs in general. This year, they lag. Custom and semicustom logic will grow only 7% to $2.74 billion, compared with 28% in 1988.

Custom logic continues to be the largest segment at $1.33 billion, up 4% over 1988. The standard-cell category is expected to increase by 10% in 1989 to $510 million. Dragging down overall growth rates is the much poorer performance of gate arrays and programmable logic. *Electronics* predicts that after a 29% increase to $900 million in 1988, gate array sales in 1989 will grow only 9% to $980 million. For programmable logic the drop is even more precipitous: following a year of 30% growth, this category will rise just 9% to $425 million.

Softening of demand in the PC market is the most significant factor in this rapid deceleration, says David Laws, vice president of marketing at Altera Corp. in Santa Clara, Calif. CMOS-based reprogrammable logic will take an especially sharp nosedive, growing 9% to $110 million, compared with last year's 120% gain. But fuse-programmable bipolar logic devices, with their much larger user base, create some steadiness. They will grow 9% to $315 million, only a slight lessening in momentum from last year's 14% growth rate.

32-BIT MICROPROCESSORS



SOURCE: ELECTRONICS

Reflecting both the softening in the semiconductor market and a loss of market share to gate arrays and programmable logic, standard logic sales will decline 1.5% this year. *Electronics* projects a decrease to $1.047 billion from last year's $1.063 billion.

On the CMOS side, high-speed logic will be down a half a percentage point to $103 million and standard CMOS logic will fall 5% to $145 million. Balanced against these losses are dramatic gains in biCMOS interface logic, up 200% in 1989 to $15 million, and advanced CMOS logic families, rising 74% to $27 million.

……

CUSTOM & SEMICUSTOM ONCE LED IC GROWTH; THIS YEAR, THEY WILL LAG

……

On the bipolar side, the only area of any significant growth is in high-speed logic, where *Electronics* predicts a 6% increase to $273 million. By comparison, low-power Schottky and standard Schottky logic should continue to lose, with consumption down 6% and 25%, respectively.

Like a rock amid a sea of change, linear ICs will continue on their slow, steady growth path in 1989, rising by 12% to $2.33 billion during 1989, a slight increase over 1988's 11% gain. One reason is that linear circuits, unlike almost any other segment, do not depend on any one market for sales. Another reason is that linear ICs are at about the stage digital ICs were in during the transition from medium- to large-scale integration.

Key areas for increased integration are analog switches, multiplexers, and communications circuits such as codecs—all segments that *Electronics* pegs for improved growth in 1989. In analog switches, sales should increase 17% to $160 million, more than doubling 1988's 7% growth rate. In communications, sales should increase by 26% to $220 million, compared with 1988's 12%. Multiplexers are set to climb 15% to $31 million, against 1988's 4% growth rate.

A loss of momentum is likely in sample-and-hold circuits and smart power ICs. From 27% growth in 1988 to $38 million, the stand-alone sample and hold will grow only 3% to $39 million, mainly because functions are being integrated on-chip. Power ICs will do better, rising 15% to $550 million after 20% growth in 1988. Here again the culprit is the PC market, where such devices find wide use, says Daniel Queyssac, president of SGS-Thomson USA in Phoenix, Ariz. □

U.S.
MARKET
REPORT

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Eratosthenes

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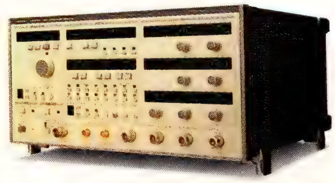

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Circle 101

STEADY AS SHE GOES AFTER BOOMING '88

Sales of semiconductor production equipment surged over 50% in the U. S. last year. That surge is deceptive in appearance, however, because in 1987 the market was in the doldrums after taking a dive in 1986, and still not up to the $2.7 billion level it had reached in 1985. In 1988, U. S. semiconductor manufacturers were doing very well and had cash on hand, so many of them, after holding back for two years, bit the bullet and set up new fab lines to build chips with next-generation technology. Steppers and other machines for building submicron CMOS are far more expensive than previous-generation systems, so they had to bite the bullet hard. Equipment sales, as a result, shot up past the 1985 high-water mark to $4.025 billion.

No one expects another 50% growth year for chip-fab equipment in 1989. The industry would be doing quite well to sustain the total market size it achieved last year, since 1988 was such a good year. In fact, the *Electronics* survey projects that the market will grow slightly, about 7% overall. That's a big falloff in growth rates, but put into historical perspective, it's no disaster. In Japan, by contrast, the market is expected to actually decrease in size some 10% in 1989.

The semiconductor equipment market is currently dominated by four segments: lithography, wafer processing, test, and assembly. Most processing experts thought that optical lithography would be superceded by X-ray or electron-beam lithography once minimum line widths of integrated circuits shrank to the level found in today's 1- and 4-Mbit dynamic random-access memories. So far, though, technical advances have enabled optical step-and-repeat systems to routinely produce submicron devices.

As a result, optical steppers still owned 58% of the lithography market in 1988. X-ray lithography systems, once thought to be the next production tool for advanced VLSI, accounted for only 6%. E-beam systems, with a 12% market share, are mainly confined to mask making, along with research and development. Straight optical projection lithography represents 18% of this market. However, it should gradually start giving way to the stepper, unless technical breakthroughs allow this high-throughput machinery to compete with the stepper's submicron capability.

In the field of wafer processing, which includes furnaces, etching systems, deposition systems, and other equipment, the exceptional 59% growth in 1988 is expected to cool down to a 4% growth in 1989. Etching and deposition systems form a sizable part of this market segment—and it's a big segment, expected to hit $1.25 billion this year.

Etching and deposition systems are still selling well, according to John Salzer, president of Salzer Technology Enterprises Inc., Santa Monica, Calif. He sees plasma etchers, for example, still on an upward sales curve, growing at about a 23% annual rate.

Salzer predicts a shift toward chemical-vapor-deposition systems over the next two or three years. In 1987, he says, CVD had a 40% share of the deposition market, with sputtering and epitaxial deposition each holding about 30%. By 1992, Salzer sees CVD increasing to 44% of the deposition market figure. In plasma etchers, he sees automated in-line single-wafer machines gaining ground over batch systems, jumping from 48% of that market to 59% by 1992.

Sales of equipment for IC assembly also hit a new high in 1988, marking $439 million in sales and a 23% increase over the previous year. Like the other categories, it will grow more slowly in 1989, at a 7% rate, with sales climbing to $471 million. World sales of assembly equipment could hit $666 million by 1992, predicts Subash Khadape, president of Semiconductor Technology Center in Neffs, Pa. Sales in the U. S. will account for approximately 71% of that, he says. □

SEMICONDUCTOR PRODUCTION EQUIPMENT

	(millions of dollars) 1987	1988	1989
Assembly (wirebonders, etc.)	358	439	471
Lithographers, total	432	678	727
Contact (proximity)	26	40	43
Direct wafer-stepping	250	395	425
Electron-beam	50	81	85
X-ray	28	42	45
Projection	78	120	129
In-line handling (scrubbers, etc.)	77	118	125
Mask generation (digitizers, etc.)	24	38	41
Wafer preparation (crystal growers, etc.)	23	35	41
Wafer processing (furnaces, etc.)	757	1,200	1,250
Test, handling, process monitoring	985	1,517	1,630
SEMICONDUCTOR PRODUCTION EQUIPMENT, TOTAL	**2,656**	**4,025**	**4,285**

All figures in current U.S. dollars.

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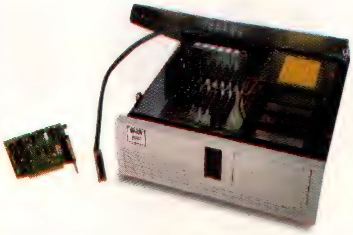

The PC Expander (PCI-20055H series) features easy-access 7-slot board expansion capacity with fan-cooled 200W power supply. Permits up to 600 channel data acquisition systems. Accepts other PC compatible expansion boards. PCI-20063A-1 host interface board required.

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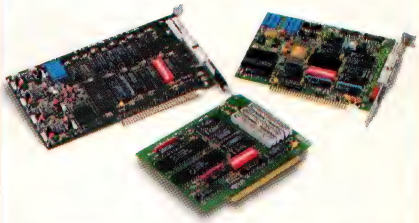

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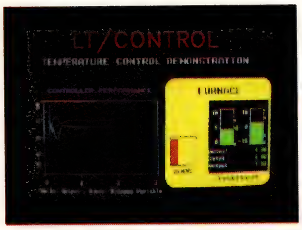

LT/Control software (PCI-20097S-1) provides process control, data logging and process monitoring. Provides for full-color animated, customized process-flow diagrams in real-time. Open loop and closed loop (PID) control algorithms included. No programming skills needed.

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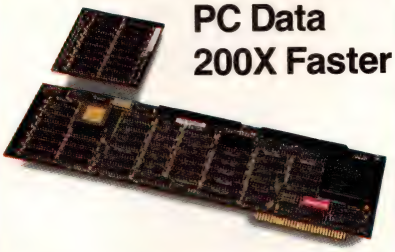

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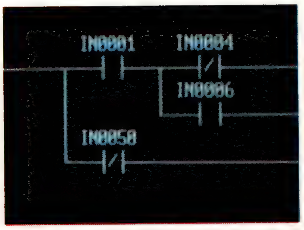

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PLENTY OF REASONS FOR LOW GROWTH

U.S.
MARKET
REPORT

Components suppliers and industry analysts agree on one thing: 1988 was a great year. And while they all expect moderation this year, they part company on how much momentum will be lost in 1989.

Total U. S. sales in 1988 were $27.9 billion, compared with $25.5 billion for 1987. That adds up to 9% growth. But projections for 1989 range all the way from a flat year to a year of near-double-digit growth.

The divergence is caused by differing evaluations of external factors, ranging from the overall business cycle to the downturn in personal computer sales. Most of the economic data indicates a downward trend, so *Electronics* is projecting growth of only some 4% for components, up to $28.9 billion.

Ironically, one simple reason a low growth rate is likely this year is that components did so well last year. A base of $27.9 billion makes it hard to sustain a steep growth rate.

But the main reason is the timing of the business cycle. Hints of what is likely to lie ahead for 1989 began to emerge in the third quarter of 1988, when component orders started to soften. Many sources say the ensuing weaker sales were not just a typical seasonal pullback, but in fact signaled the slowdown that is widely expected throughout the industry.

The slowdown was seen first and most seriously in components such as printed-circuit boards and power supplies intended for personal computers and peripherals, especially disk drives. The softening in pc board orders is particularly significant. Boards go into virtually all types of equipment, so a slump for them is usually a reliable indicator of weakness throughout the industry. They also make up the largest segment of the components business.

Conversely, accelerating sales for pc boards can drive the growth of components overall. That is what happened in 1988. At the beginning of the year, the *Electronics* projection called for a 9% growth rate for components. By the middle of the year,

COMPONENTS

	(millions of dollars) 1987	1988	1989
Capacitors, total	**1,381**	**1,496**	**1,544**
Ceramic	414	430	433
Chip	138	170	180
Electrolytic, total	497	547	570
Aluminum	164	180	188
Tantalum	333	367	382
Film & paper	276	292	303
Glass & vitreous enamel	14	15	16
Mica	27	25	23
Variable	15	17	19
Character displays, total	**399**	**435**	**467**
Plasma	90	93	96
Light-emitting-diode	94	100	104
Liquid-crystal	120	132	145
Vacuum-fluorescent	95	110	122
Connectors, total	**3,772**	**4,108**	**4,299**
Coaxial (excluding subassemblies)	351	382	400
Cylindrical, total	633	689	727
Miniature	260	282	296
Standard	165	182	192
Subminiature	208	225	239
Fiber-optic	55	63	70
Flat-cable	385	414	435
Insulation-displacement	292	313	328
Printed-circuit edge connectors	770	862	897
Rack & panel	628	675	702
Special-purpose	658	710	740
Crystals, total	**215**	**228**	**235**
Assemblies (including mounts & ovens)	155	168	177
Discrete crystals	60	60	58
Electron tubes, total	**2,222**	**2,349**	**2,435**
Cathode-ray (excluding TV)	122	128	135
Power & special-purpose, total	941	959	971
Gas & vapor	42	43	44
Klystrons	102	103	104
Light- & image-sensing	272	278	280
Magnetrons	45	47	49
Traveling-wave tubes	340	344	348
Vacuum	140	144	146
Receiving	28	26	23
TV picture, total	1,131	1,236	1,306
Color	1,100	1,210	1,283
Monochrome	31	26	23
Hybrid & modular components, total	**1,273**	**1,304**	**1,240**
Active filters	30	31	30
Custom hybrids & modules	1,050	1,074	1,020
Data-acquisition boards	6	7	8
Data conversion, total	107	111	105
A-d converters	60	62	59
D-a converters	40	41	39
Sample & hold	7	8	7
Instrumentation & isolation amplifiers	20	20	19
Operational amplifiers	60	61	58
Magnetic, total	**953**	**990**	**1,018**
Af & rf transformers, coils, & chokes	210	212	216
Ferrite components (coil forms, cores, etc.)	108	110	113
Power transformers	350	357	363
TV components (including yokes and feedback circuits)	285	311	326
Microwave components, total	**448**	**470**	**475**
Amplifiers	192	204	206
Detectors	30	32	32
Ferrite devices	106	108	109
Mixers	58	61	62
Passive components, total	62	65	66
Coaxial & strip-line	49	51	52

though, pc-board growth had surged to more than 20%. By most accounts, the boom in personal computers and their peripherals accounted for most of the board sales. Although the PC business turned downward in the second half of 1988, the momentum it had gathered in the first half was enough to push overall components growth for 1988 to 9%; pc boards themselves grew by 15%, reaching $5.9 billion in sales, up from $5.1 billion in 1987.

It appears, however, that 1989 will see precisely the opposite phenomenon. Weak orders for pc boards are likely to drag down the overall growth rate of components. The *Electronics* survey projects pc-board consumption will reach $6.1 billion, for a modest growth rate of a little less than 5%.

A somewhat more positive outlook is that of Kent Webb at the consulting firm of Analytics in Palo Alto, Calif. Webb agrees that "printed-circuit boards track overall demand pretty closely" and that the capital spending cycle is entering a downward cycle. Nevertheless, he predicts that components sales will grow by 6% in 1989, down from the 10.8% he recorded for 1988. That growth depends on 7.5% growth for pc-board sales—something most other sources do not now foresee.

Webb's projections at the end of 1988 show the book-to-bill ratio for components remaining at less than 1.0 until well into the first quarter of 1989. This key ratio dropped into negative territory in August, about the same time that component makers were reporting that orders were drying up.

WEAK ORDERS FOR PC BOARDS MAY HOLD THE MARKET BACK

Where the Analytics forecast differs from others is in showing a strong upswing in the second quarter of 1989. Webb says that recent reports from the Bureau of Economic Research foreshadow the second-quarter upsurge with some improvements in capital spending that are starting to become apparent. He therefore is holding to his 6% forecast for 1989, even in the face of the negative mood of much of the rest of the industry.

A more typical view is held by Ray Prichard. He says that 1989 will be "one of those years close to flat. That's what my 35 years in this business tells me." More than his years in the business go into his prediction: Prichard is executive vice president of Chicago's industry-wide Interconnection and Packaging Council. IPC gathers data from some 1,700 worldwide companies in its field, studies leading economic indicators, and passes its resulting predictions to a team of outside authorities for further study.

The outlook is not entirely pessimistic. Another class of components, power supplies, follows much the same pattern as pc boards. As equipment sales rise or fall, so do power-supply orders, and for much the same reason: power supplies are a component of virtually every kind of equipment. It's not surprising, then, that supplies registered the same rate of growth last year that pc boards did—16%, with sales in the noncaptive market rising from about $2 billion in

	(millions of dollars)		
	1987	**1988**	**1989**
Waveguide	13	14	14
Passive filters & networks, total	**270**	**287**	**283**
RC networks	32	35	35
Rfi & emi filters	152	160	158
Other	86	92	90
Power supplies (noncaptive), total	**1,982**	**2,298**	**2,450**
Switching	862	935	989
Linear	363	356	334
Uninterruptible	757	1,007	1,127
Printed circuits and interconnection systems, total	**5,693**	**6,560**	**6,846**
Interconnection systems, total	627	712	740
Chip carriers	42	68	83
Backplanes	270	304	310
Socket & socket panels for DIPs	315	340	347
Printed circuits, total	5,066	5,848	6,106
Flexible circuits	345	360	366
Rigid boards, total	4,721	5,488	5,740
Double-sided	1,445	1,600	1,680
Multilayer	2,900	3,490	3,665
Single-sided	376	398	395
Relays, total	**709**	**731**	**746**
Crystal-can	128	129	130
General-purpose	234	235	237
Reed	68	74	75
Solid-state	66	73	79
Telephone-type	44	44	43
Time-delay	20	21	22
Rf	149	155	160
Resistors, total	**1,067**	**1,111**	**1,136**
Fixed, total	528	559	582
Chip	35	38	40
Composition	51	56	49
Deposited-carbon-film	22	20	19
Metal-film	220	242	266
Wirewound	200	203	208
Resistive networks, total	113	124	129
Thick-film	101	110	113
Thin-film	12	14	16
Thermistors	80	84	85
Variable, total	346	344	340
Potentiometers	106	109	112
Trimmers	240	235	228
Switches & keyboards, total	**1,256**	**1,296**	**1,313**
Dual-in-line	68	72	74
Keyboards, keypads, & matrices	492	521	531
Lighted	153	154	155
Push-button	159	162	164
Rotary	74	75	76
Slide	48	49	49
Snap-action	116	117	118
Thumbwheel	35	36	36
Toggle	111	110	110
Transducers, total	**1,302**	**1,388**	**1,467**
Flow	135	140	143
Fluid-level	134	143	182
Motion (linear & angular)	155	170	178
Pressure (air, liquid, and mechanical)	641	685	719
Temperature (excluding thermocouples & thermistors)	237	250	245
Wire & cable, total	**2,598**	**2,829**	**2,966**
Coaxial cable	533	565	587
Fiber-optic cable	743	832	890
Flat cable	122	130	136
Hook-up wire	322	354	377
Multiconductor cable	878	948	976
COMPONENTS, TOTAL	**25,540**	**27,880**	**28,920**

All figures in current U.S. dollars.

1987 to $2.3 billion last year.

However, it looks as if power supplies might get through the year in better shape than pc boards. *Electronics* is projecting about 7% growth in 1989, up to $2.5 billion, but several power-supply executives expect sales will go higher. They cite several trends now under way that ought to help them get through the soft market of 1989. With those trends in mind, for example, Irving Gutman, vice president for sales and marketing at the Lambda Group of Veeco Instruments Inc., Melville, N. Y., predicts that domestic power-supply sales will grow about 10%. Lambda, with more than $200 million in annual sales, is by far the largest player in the field, where more than than 100 U. S. companies compete.

The main factor driving the supply business is power density improvements, which began seriously about two years ago and have forced upgrading of all product lines. "The game now is cramming more and more into the box, just to keep up," says Bruce E. Hamilton, vice president of marketing and engineering at ACDC Electronics, a division of Emerson Electric Co. in Oceanside, Calif. It is common now to have 400 W in a single box, compared with under 400 W in two boxes a couple of years ago, he says.

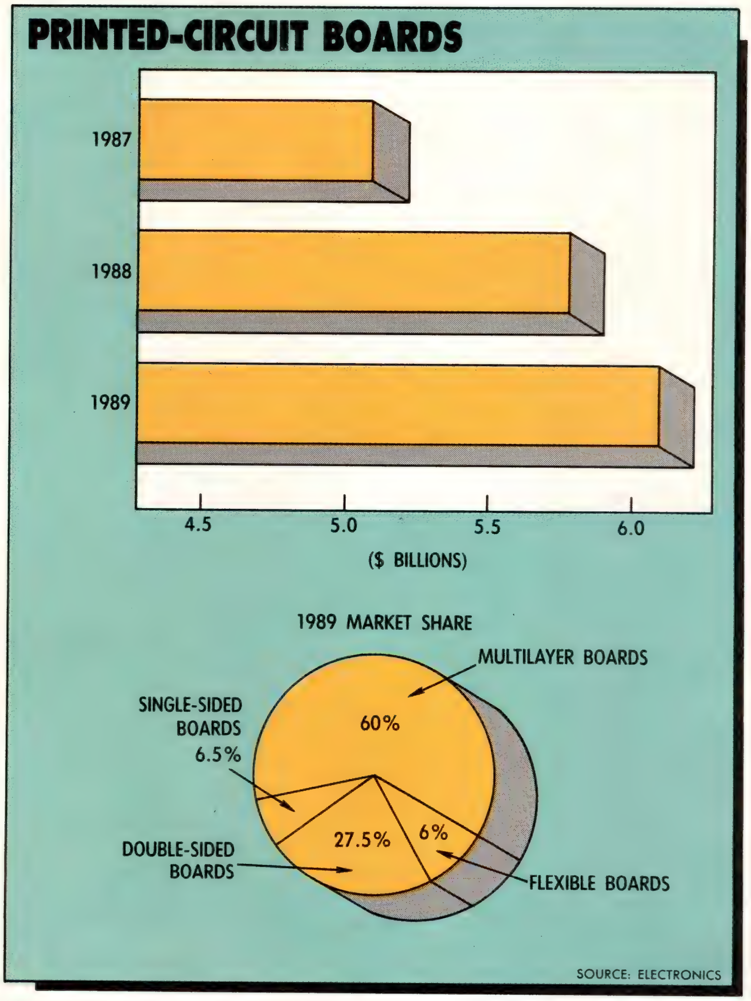
Overall, power density has improved tenfold in the past two years, says Peter J. Price, chief executive of the Power Supplies Group of Unitech plc, which is headquartered in the United Kingdom and includes Qualidyne Systems Inc. in San Diego. Density has gone from 3 W/in.^{3} two years ago to 30 W/in.^{3} today. On the other hand, prices have steadily declined—Hamilton at ACDC estimates by 10% a year—so increased unit sales don't necessarily add up to increased revenue. Somewhat offsetting the decline in prices is the presence of an increasing number of users who once bought from captive suppliers but more and more frequently are going into the merchant market.

The main factor affecting the power-supply industry has less to do with power supplies than with the industry itself. The trend is toward consolidation, led by Price's Unitech. At the end of 1988, Unitech was finishing up its acquisition of Veeco, which owns Lambda. The buyout will create by far the largest independent manufacturer of power supplies for the world market, with sales approaching $300 million. Smaller competitors will find it increasingly difficult to keep up with such a well-financed, dominant rival, industry watchers believe.

Also growing faster than predicted last year were connectors, where sales rose from $3.8 billion in 1987 to $4.1 billion in 1988, for a growth rate of about 9%, compared with the expected 6%. "The faster growth was in the high-performance lines, which are driven by the need for high density," says Dominic J. Pileggi, president of Thomas & Betts Corp.'s electronic division in Bridgewater, N. J. This year sales should rise again, to $4.3 billion, a 5% gain.

Electron tubes continued to grow slowly during 1988 compared with the overall components market. Electron tube sales rose from $2.2 billion in 1987 to $2.3 billion, a rise of about 6%. The *Electronics* survey predicts that growth will be even slower this year, with sales inching ahead to $2.4 billion, about a 4% rise.

Among the worst performers will be hybrid and modular components, a maturing market. *Electronics* predicts their sales will actually decline, to $1.2 billion in 1989 from $1.3 billion last year. Compared with the 2% growth last year, the market will drop by almost 5%. ☐


PRINTED-CIRCUIT BOARDS

SOURCE: ELECTRONICS

No. 1

Watt's Up™ from Semiconductor Circuits, Inc.

New DC/DC Converter Series Delivers 3.6 Watts in a 24-Pin DIP Compatible Package

The pioneering technology leader in encapsulated power converter modules, Semiconductor Circuits, Inc. introduces the DPU series, with up to 3.6 watts of power in a size more typical of one watt converters.

	Semiconductor Circuits, Inc.	Competitor A	Competitor B	Competitor C
Power	1.5 to 3.6 watts	1 watt	1 watt	1 watt
Package Size	1.25 x .8 x 0.375 inches	1.27 x .62 x .4 inches	1.25 x .8 x .4 inches	1.25 x .8 x .4 inches
Isolation	500 Vdc	500 Vdc	500 Vdc	300 Vdc
Short Circuit Protection	Yes	Yes	Output Thermal	Yes
Reliability (MBTF)	> 1,000,000 hrs	300,000 hrs	unpublished	unpublished

The new DPU series incorporates our extensive MOSFET design experience, for a power unit that operates cooler and more reliably than traditional designs.

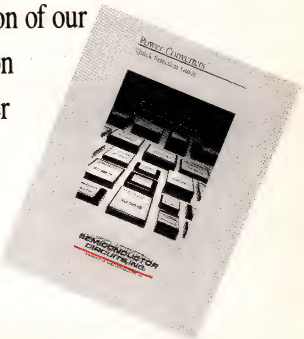
With a mean time between failure exceeding 1 million hours, and continuous short circuit protection, the new DPU series is the low cost power converter that you can rely on.

OEM power supply designers can look to the DPU series for up to 3.6 watt operation, with either single or dual output designs. Input voltage range is 4.75 to 5.25 Vdc. The DPU series incorporates an LC input filter and offers 500 Vdc of I/O isolation.

The DPU series offers designers a range of output voltages: 5, 9, 12, and 15, as well as ±12 and ±15 Vdc.

And all these features and capabilities come in a 24-pin DIP-compatible package measuring only 1.25″ by 0.8″ by 0.375.″

At just $16.50* in OEM quantities, the DPU series is a real, U.S.-made bargain for system designers. For more information on how to put the price/performance star to work in your dc-to-dc conversion application, please contact your nearest Semiconductor Circuits, Inc. distributor or representative. Or call us direct in New Hampshire, at (603) 893-2330. And be sure to ask for the latest edition of our Quick Selection Guide to Power Converters.



*Price in U.S. Dollars

SEMICONDUCTOR CIRCUITS, INC.
SUBSIDIARY OF EMERSON ELECTRIC CO.
49 Range Road • Windham, New Hampshire 03087
Circle 107

NEAX61 CO SWITCH: NOW IN SERVICE AT 1,096 EXCHANGES IN 47 NATIONS.

Around the world, NEAX61 digital switching systems are serving as the core of expanding digital networks – the foundation of the ISDN future.

Since its introduction in 1979, the NEAX61 has been installed at 1,096 exchanges in 47 countries. Reasons include the system's ISDN-oriented modular hardware/software, advanced service features, and outstanding operation and maintenance support. Worldwide acceptance and field-proven technology demonstrate that the NEAX61 is one of the leading central office switches in today's highly-competitive telecommunications industry.

The NEAX61 is now produced in Argentina, Brazil, Japan, Malaysia and the USA. Future production plans include Thailand and Venezuela. Intensive software development, involving an ever-larger number of engineers, is underway in Argentina, Brazil, Japan, Malaysia, New Zealand and the USA.

The NEAX61 responds to two of the most difficult problems faced by telecom administrators: soaring traffic volume and strong demand for new services. The solution is greater switching capacity, and the NEAX61 provides just that with the most powerful processor in the telecom world.

The heart of the system is the CP8Z – a 32-bit custom VLSI that offers over 1,000,000 BHCA. The industry's largest call-handling capacity assures easy expansion and smooth introduction of diverse ISDN services. The enhanced NEAX61 switches are already in the field in two countries.

NUMBER 140

OAI INTEGRATES COMPUTER AND PBX FOR NEW SERVICES.

NEC is introducing a revolutionary gateway interface that enables an external computer to control and extend the operation of a digital PBX. The Open Application Interface (OAI) greatly enhances the data processing power of the PBX, opens many new applications and offers a higher level of user services.

OAI is designed to link the NEAX 2400 Information Management System with most computer systems. Control resides with the computer.

OAI allows two-way data exchange between the PBX and computer. This opens a new world of integrated information services. Multi-function telephones become handy data terminals. Like workstations, they can send or receive data from the computer.

Among the many new OAI services that can be easily implemented are: order entry, inventory management, free location numbering (which allows you to direct your calls to any telephone on the network), and electronic telephone directories.

OAI is accessible to most computer systems because it employs a standard protocol conforming to the OSI (Open Systems Interconnection) model established by the ISO (International Standards Organization).

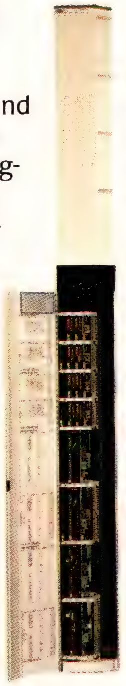
OAI is supplied as an option with the NEAX2400 IMS and comes with a library of programs that translate standard programming instructions into commands recognizable by the NEAX 2400 IMS processor.

NEW-GENERATION DIGITAL MULTIPLEX AND LINE SYSTEMS.

In the age of digital networks for new services, multiplex equipment must offer a higher level of performance.

Our new N6000 Series multiplex and line systems meet present needs and future demands. They provide leading-edge performance and economy for any network application. N6000 systems incorporate the latest custom digital and analog LSI devices for outstanding reliability. Surface-mount technology and compact unit design dramatically reduce system dimensions and increase flexibility.

The N6000 Slim Rack, measuring 240(W)x2,600(H)x255(D)mm, allows mounting of Multiplexers (MUX) and Optical Line Terminals (OLT) on the same rack. For example, one Slim Rack accommodates a complete equipment set for a 140M fiber optic transmission system — 1 system of 140M OLT with 1 x 1 line protection, 1 system of 140M MUX, 4 systems of 34M MUX, 16 systems of 8M MUX and an orderwire. Further, the 8M and 34M MUX system units fit on the same shelf. Thus a variety of systems for skip, drop/insert and other applications can be built into one shelf.



The N6000 Slim Rack features a side cable duct. It simplifies rewiring for expansion and modification. The Slim Rack centralizes all system alarm and control functions in one maintenance terminal.

The N6000 Series complies with the latest CCITT Recommendations. Compatibility with future requirements, such as TMN (Telecommunications Management Network) and private Network Management System applications, is part of the N6000 concept. For example, standard features of the 140M OLT include a 64kb/s service data channel port and a 1,200b/s service channel port for access to a total Network Management System.

NEW LDs OFFER STABLE SLM OPERATION.

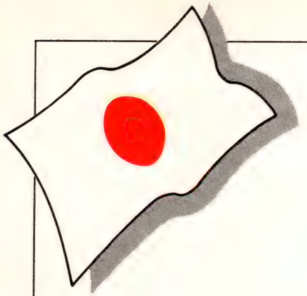
The key to implementing lightwave communication systems with giga-bit speed is the stable single-longitudinal-mode (SLM) oscillation of laser diodes.

NEC opens the way with new 1.3/1.55μm phase-shifted distributed feedback laser diodes. They feature a diffraction grating with a $\lambda/4$-shifted region in the center. This unique grating design produces a stable single wavelength over a wide temperature range: 5°C to 50°C. The sub-mode suppression ratio is 35dB, typical.

Our new light sources offer high output power and fast operation: 8mW (typ) for the 1.3μm NDL5600 and 5mW (typ) for the 1.55μm NDL5650. Rise and fall times for both types are 0.2ns (typ).

The laser diodes come in hermetically-sealed can-type packages with an integral monitoring photo diode or ribbon-leaded chip-on-carriers.

NEC



JAPAN

THE RISING SUN KEEPS ON SHINING

This year, like 1988, should see Japan's equipment and component consumption outdoing the major markets around the world. Also repeating the 1988 results, Japan's market-growth rates should top those of the U. S. by a few percentage points. Japanese equipment markets are going to increase 12%, to $157.7 billion, according to the *Electronics* market survey, against 9% in the U. S. And on the components front, the increase in Japan is pegged at 7%, to $47.6 billion, versus 4% for the U. S. (The *Electronics* survey used an exchange rate of 125 yen to the dollar both this year and last.)

In equipment and software, where consumption increased 15% last year, growth in 1989 will be driven by the data-processing and software industries, which together account for more than 60% of total equipment shipments. Their increase is forecast at just under 15%, matching last year's, which will bring them to $75.9 billion, the *Electronics* survey indicates. Activity in the data processing market will range across the spectrum, with the peaks coming in sales of personal computers, Unix work stations, and supercomputers.

Industrial equipment will grow just 5% to $9.8 billion after last year's 38% spurt, mostly because semiconductor manufacturers' purchases of equipment in 1989 won't grow as they did during their 1988 buying spree, when they were trying to ramp up production to meet memory-chip demand. Also, robot sales growth will be off marginally.

In test and measurement equipment, the huge automatic-test-equipment segment overshadows everything else. T&M is expected to repeat last year's 13% growth rate, to $1.8 billion.

JAPAN EQUIPMENT

	(millions of dollars) 1987	1988	1989
Consumer electronics, total	**24,921**	**26,866**	**29,119**
Audio equipment, total	7,383	8,196	8,462
Car	1,308	1,384	1,389
Compact-disk players	397	394	383
Phonographs & radio-phonographs	6	6	5
Radios (table, clock, and portable)	106	102	98
Radio/recorder combinations	904	1,078	1,166
Stereo equipment, total	3,964	4,503	4,680
Components	1,063	1,151	1,200
Compact systems	1,011	1,120	1,178
Consoles	1,890	2,232	2,302
Tape recorders & players	698	729	741
Personal portable	473	508	522
Standard cassette	225	221	219
Home video equipment, total	10,774	11,381	12,688
Camcorders	1,048	1,402	1,736
8-mm	501	636	744
1/2-in.	547	766	992
Cassette players & recorders	4,899	5,084	5,332
8-mm	67	64	64
1/2-in.	4,832	5,020	5,268
Cameras	26	24	24
Video-disk players	377	490	680
Capacitive-pickup	75	48	24
Laser-pickup	302	442	656
TV receivers, total	4,424	4,381	4,916
Color	4,379	4,334	4,859
Monochrome	7	2	1
Projection	38	45	56
Other consumer products, total	6,764	7,289	7,969
Calculators (personal and professional)	380	502	554
Games (video and nonvideo) & toys	2,101	2,180	2,580
Home computers (under $1,000)	256	256	256
Home-computer peripherals	4	4	4
Home intercom systems	93	107	117
Home kanji word processors	1,542	1,715	1,872
Microwave ovens	909	971	997
Musical instruments	484	503	504
Telephone-answering devices	232	235	244
Watches & clocks	763	816	841
Communications equipment, total	**15,182**	**17,246**	**18,998**
Data communications equipment	3,200	4,000	4,800
Facsimile terminals	1,764	1,947	2,093
Fiber-optic communications systems	400	480	564
Intercom systems	60	66	73
Paging systems, public & private	463	633	674
Radar (air, land, & marine)	296	272	278
Radio, total	2,266	2,591	2,954
Broadcast equipment	412	433	452
Land-mobile (mobile & base stations)	796	935	1,014
Marine-mobile (ship & shore stations)	139	164	167
Microwave	798	826	873
Satellite earth stations	121	233	448
Telecommunications equipment, total	5,549	5,985	6,170
Customer-premise equipment	1,923	2,017	2,121
Telephone & data-switching systems, private	640	700	747
Telephone & data-switching systems, public	1,605	1,839	1,812
Transmission & carrier equipment	1,381	1,429	1,490
Television equipment, total	1,184	1,272	1,392
Broadcast	240	256	272
CATV	304	320	360
CCTV (including educational, industrial, medical)	640	696	760
Data processing & office equipment, total	**57,718**	**66,012**	**75,857**
Data processing equipment, total	35,652	40,559	46,664
Personal computers (under $5,000)	2,539	2,869	3,245
Technical work stations	2,647	3,213	4,087
Office computers	3,367	3,704	4,068
Minicomputers ($20,000 to $100,000)	1,318	1,367	1,396
Superminicomputers ($100,000 to $400,000)	2,381	2,757	3,387
Mainframe computers ($400,000 to $5 million)	23,104	26,264	29,944
Low-end	4,588	5,116	5,876
Medium-range	9,220	10,292	11,796
High-end	9,296	10,856	12,272
Minisupercomputers	18	40	88
Supercomputers (over $1 million)	278	345	449
Data-input peripherals	203	237	284
Data-output peripherals	5,695	6,840	8,062

ATE will also repeat 1988's growth, up 19% to a 1989 total of $841 million—to keep up with the increased production of semiconductors and the boards into which they go. Communications systems growth, 10% to $19 billion, will be off compared with last year's 14%; common carriers are taking a deep breath before they charge headlong into the market for integrated services digital networks.

Consumer electronics continues to shrink as a percentage of the total, but growth will be virtually the same as last year, 8% to $29.1 billion. Camcorders, videodisk players, home kanji word processors, and even broadcast satellite antennas and converters are among the products that the consumer will carry home. Large-screen TV sets with enhanced definition will probably be shipped.

But the real thirst in Japan appears to be for computer equipment, from super to personal, and there are no signs it is being slaked. In supercomputers, the growth rate of 30%, to $449 million, will top last year's 24%. New machines will aid the growth: Fujitsu Ltd. announced a new machine as 1988 ended and NEC Corp. could have one this year.

Japanese computer makers, however, have neglected minisupers, the system of choice for those who can't afford a standard supercomputer. U. S. manufacturers are filling the gap as the market niche explodes—it is expected to grow 120% this year, to $88 million, after last year's 122% growth. One of the U. S. manufacturers now in the market, Convex Computer Corp. of Richardson, Texas, will go a step further as its importer, Tokyo Electron, begins assembling the product in Japan and selling it at a lower price.

EQUIPMENT GROWTH, DRIVEN BY COMPUTERS, WILL DROP A BIT

The traditional mainstay category, large mainframes, will see growth of 14% to $30 billion, driven by new applications in strategic-information and computer-integrated-manufacturing systems. The growing need for transaction processing on international financial networks will help, too.

Kunio Okuwa, manager of NEC's EDP product planning department, says that there is a growing need for small and medium-size mainframes to be used as department and distributed processors. Shipments of each class are expected to grow 15%, to $5.9 billion for the low-end machines and to $11.8 billion for the medium-size models. There is another overlapping class of computers, which the Japanese call business or office computers. Their machines are also used as stand-alone entry-level computers for new customers. Forecast for a 10% rise to $4.1 billion, they are typically used with packaged

	(millions of dollars)		
	1987	1988	1989
Computer-output microfilm	40	42	45
Displays	1,311	1,460	1,629
Plotters	272	404	492
Printers, impact	2,630	3,113	3,551
Printers, nonimpact	1,159	1,501	1,983
Other data-output peripherals	283	320	362
Data-storage subsystems	6,714	7,794	9,112
Flexible disks	993	1,153	1,328
Hard disks	4,226	5,020	5,994
Magnetic tapes	1,195	1,246	1,302
Optical-disk systems	124	175	256
Other data-storage subsystems	176	200	232
Data terminals	5,288	5,944	6,697
CRT	1,375	1,522	1,700
Other (teleprinters, remote-job-entry, etc.)	3,913	4,422	4,997
Electronic office equipment, total	4,166	4,638	5,038
Copying equipment	1,193	1,347	1,407
Facsimile transmission systems	1,391	1,505	1,632
Kanji word processors	1,582	1,786	1,999
Industrial equipment, total	**6,824**	**9,388**	**9,820**
Inspection systems (ir & X-ray)	320	280	400
Process-control systems	1,532	1,616	1,720
Programmable controllers	724	844	944
Robot systems	1,448	1,768	2,116
Semiconductor production equipment, total	2,400	4,400	4,000
Assembly (wire bonders, etc.)	224	360	320
Lithography (optical, E-beam, X-ray)	520	824	640
Mask generation (digitizers, mask makers, etc.)	160	200	224
Wafer preparation and processing (furnaces, etc.)	1,496	3,016	2,816
Vision systems	400	480	640
Power supplies (noncaptive), total	**1,871**	**2,058**	**2,267**
Bench & lab	70	73	78
Industrial	48	56	58
OEM & modular, total	1,753	1,929	2,131
Linear	24	28	30
Switching	1,729	1,901	2,101
Test & measurement instruments, total	**1,415**	**1,593**	**1,798**
Analog voltmeters, ammeters, & multimeters	13	13	13
Automatic test equipment, total	599	709	841
Discrete-component testers	26	29	32
IC testers	520	616	736
Pc-board testers	53	64	73
Counters, time & frequency	42	44	46
Digital multimeters (including probes & accessories)	57	60	63
Logic analyzers	28	33	39
Microprocessor development systems	80	81	88
Dedicated	32	31	32
Universal	48	50	56
Microwave test & measurement instruments	65	69	76
Oscillators	40	44	48
Oscilloscopes	127	139	155
Power meters (below microwave frequencies)	160	178	187
Recorders & plotters, including chart and X-Y type	108	122	132
Signal generators (pulse, sweep, & function), total	31	34	37
Spectrum analyzers	65	67	73
CAD/CAE equipment, total	**560**	**700**	**856**
Engineering work stations, total	496	620	760
IC design	64	80	96
Pc-board design	128	160	192
Other engineering work stations	304	380	472
Simulation accelerators	64	80	96
Software, total	**14,064**	**16,684**	**18,992**
Microcomputer, total	1,440	1,696	1,920
Systems	480	576	640
Applications	960	1,120	1,280
Minicomputer, total	5,616	6,740	7,864
Systems	1,600	1,920	2,240
Applications	4,016	4,820	5,624
Mainframe, total	7,008	8,248	9,208
Systems	2,000	2,240	2,400
Applications	5,008	6,008	6,808
EQUIPMENT, TOTAL	**122,555**	**140,547**	**157,707**

All figures in current U.S. dollars.
Exchange rate: 125 yen to $1.

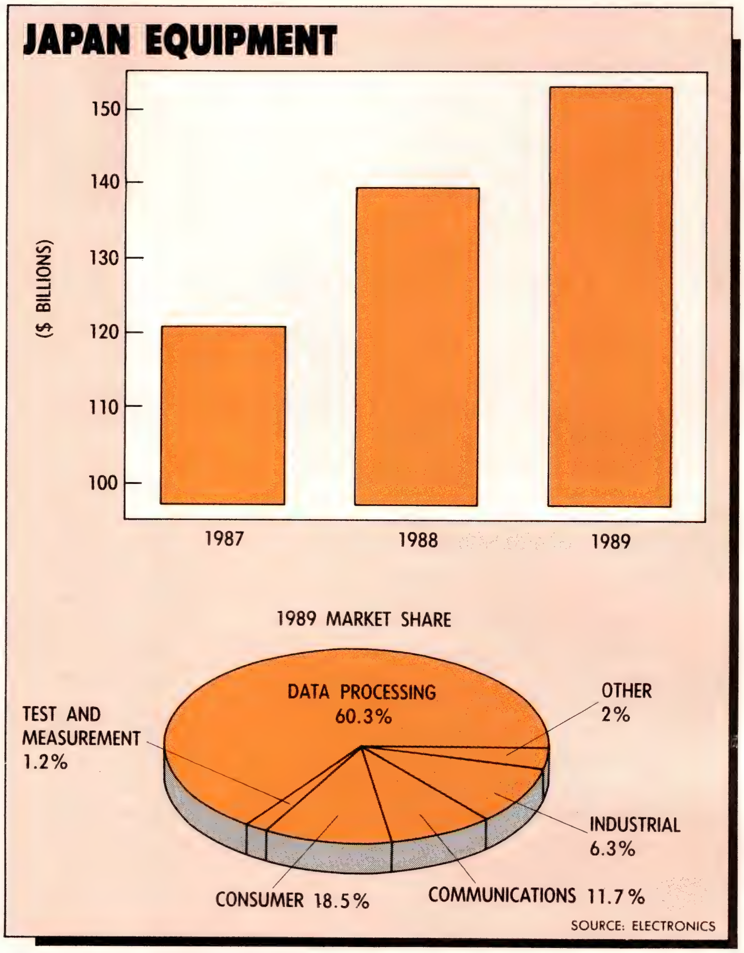
programs by companies too small to have their own staff of programmers.

In a work-station market that the survey indicates will exceed last year's 21% growth rate by increasing 27% to $4.1 billion, the magic word is "Unix." Sun Microsystems Inc. products are especially popular, and Fujitsu even sells them on a private-label basis. Sony Corp. claims that its NEWS is the leader in units sold, but the systems are toward the low end of the price range. The product Japan hopes will help it close the software gap with the U. S., the Sigma work station with its modified Unix operating system, has not yet developed into a large market. Nevertheless, the Ministry of International Trade and Industry has proposed a follow-up on Super Sigma project [*Electronics,* December 1988, p. 57].

The personal-computer market will grow 13% to $3.2 billion, forecasts the survey, matching last year's growth rate. NEC's PC 9801 still has the lion's share, but it faces strong competition. Seiko-Epson is selling compatibles in both desktop and laptop versions, and it beat NEC to market with a laptop whose screen is compatible with the desktop PC 9801.

Many companies are offering AX PC computers, including Acer (in Taiwan), Ai Denshi, Alps, Canon, Casio, Kyocera, Mitsubishi, Oki, Proside, Sanyo, and Sony. The computers, essentially AT compatibles with a special graphics board, are generally aimed at the corporate market rather than individuals. IBM continues to sell its PS/55 computers into the high-end stand-alone PC market and its own system market. Its latest hardware offering is a modified PS/2 made in Japan, but not all American software will run on it. However, rather than change its Japanese-language software as the AX manufacturers have done, IBM is counting on the compatibility window in OS/2 to tie everything together.

Adding uncertainty to the PC market is the education ministry's decision to use machines running the TRON operating system. Some critical makers point out that TRON is being implemented by a company not known for operating systems, Matsushita. Also, by the time TRON PCs without software arrive, schools will have an installed base of other types of PCs.


JAPAN EQUIPMENT

SOURCE: ELECTRONICS

Although personal computers have become extremely proficient at Japanese-language word processing, dedicated word processors continue to sell well because they are much cheaper. So shipments of these kanji machines will rise at about the same rate as last year, 12%, to $2 billion.

Data-storage subsystems will enjoy the same 16% growth rate as last year, moving to $9.1 billion. The hard-disk segment will do about the same, with the value of 1989 shipments rising 19.4%, to $1.6 billion, after 1988's 18.8% rise. Magnetic disks for large mainframes are going from 14 to 10 in. and even smaller diameters as capacity increases, and high-performance solid-state replacements for disks are also increasing. In personal computers, Japan lags behind the U. S. in the use of hard disks but is narrowing the gap. The use of rewriteable magneto-optic disks for document files is picking up speed; optical disk shipments will increase 46% to $256 million, up from last year's 41% rise.

Sales of semiconductor production equipment spurted last year as integrated-circuit manufacturers installed new lines. Demand this year will stay high, with shipments totaling $4 billion. Last year's sales were $4.4 billion, though, so this is a decline of 9%

Memory and other IC test equipment registered good growth—18% last year—and will continue to grow in 1989, rising by almost 20% to reach $736 million in sales. Oscilloscopes have almost all gone digital, but the expected 1989 value of $155 million, up 12%, is slower in growth than is ATE.

Growth in most communications categories will be only single-digit this year. The relatively low growth rate in 1989, however, conceals a great potential market, though, because the expenditures needed to bring Japan into the ISDN age is projected to total $152 billion through the year 2000. In facsimile, demand will lessen slightly in 1989, with the growth rate forecast at 7%, down from last year's 10%.

In color TV, the two main trends are large and small. Sales of sets with screen sizes of 30 in. and larger are expected to rise 12% this year to $4.9 billion after dropping 1% last year. Right now these large-screen sets take only about 5% of the total market, but they are gaining ground fast. The 22-to-29-in. midrange is increasing by about 10% a year, while smaller sets actually have a negative growth rate. However, liquid-crystal-display TVs in the 2-to-6.5-in. range should pick up nicely this year.

Growth in video cassette recorders has pretty much ground to a standstill—it is expected to be up a nominal 5% this year, to $5.3 billion—but growth in camcorders is still going strong. A rise of 24% to $1.7 billion is predicted on the heels of 1988's exhilarating 33%.

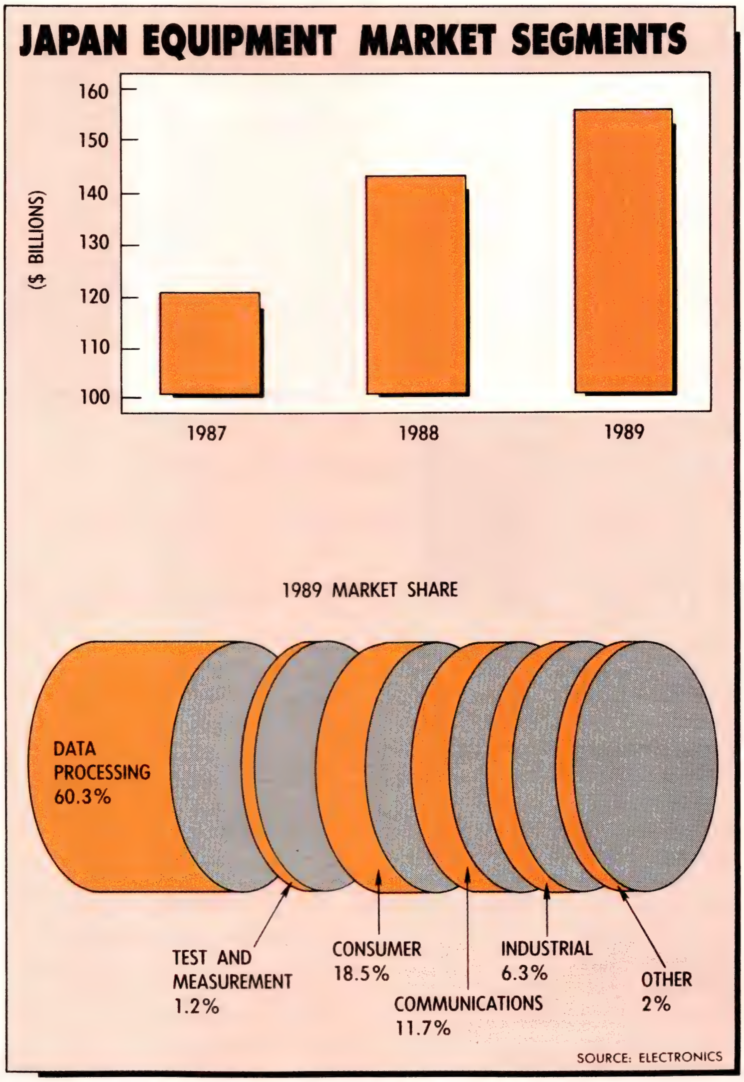
Laser video-disk players are also the scene of much action. They will be up 39% to $680 million, improving on 1988's 30%. Players are now triple-compatible for laser video disks, compact-disk video, and standard music CDs. Growth is being driven by inexpensive 200-mm laser disks that provide viewers with four musical numbers and accompanying video.

The CD-player business is being driven by portable units, which are not made by all manufacturers. The survey forecasts a 3% drop in consumption, to $383 million, but just looking at the CD-players catagory is misleading. CD players are incorporated into about 95% of all stereo sets, including the popular so-called minicompo (for miniature component) systems. In addition, an increasing number of radio-cassette players—about 35%, currently—also include CD players.

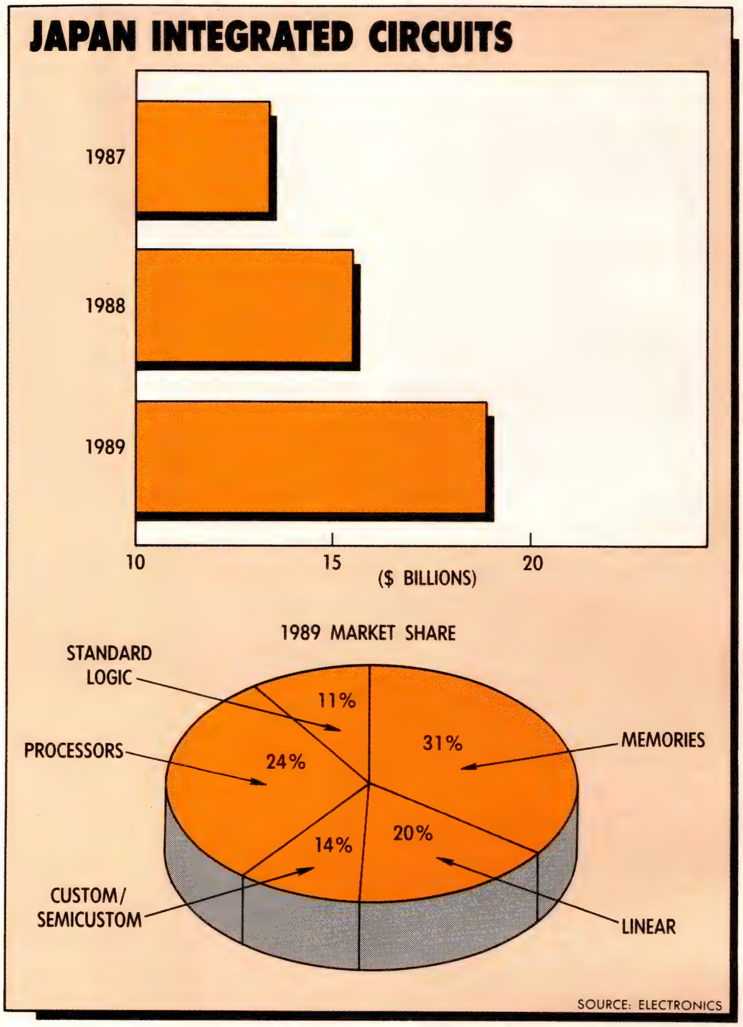
Semiconductor and component makers are facing a somewhat tighter year than their equipment counterparts. They're looking at a 1989 growth rate of less than half of last year's. The *Electronics* survey predicts semiconductor growth will be just 10%, to $21.2 billion, following an increase in 1988 of 23% to $19.2 billion. The result is that this year components overall will see an increase of 7% to $47.6 billion after a robust 14% jump last year to $44.6 billion.

The pie will grow at a slower rate than last year and every slice will be affected. One of the biggest changes will come in the memory market, where gains caused by increased shipments will be partially canceled by lower prices. Just a sweet remembrance will be last year's leap of 62% to $4.7 billion; 1989's predicted rise is 18%, to $5.6 billion.

Reflecting almost as big a change, according to the survey, will be custom and semicustom logic, and microprocessors and microcomputers. The custom and semicustom logic increase will be 12%, to $2.6 billion, after last year's jump of 23% to $2.3 billion. Microprocessor and microcomputer shipments are forecast to grow 14% to $2.4 billion on top of a 25% gain last year, to $2.1 billion. And linear ICs will be essentially flat, growing 4% this year to $3.6 billion after last year's


JAPAN EQUIPMENT MARKET SEGMENTS

SOURCE: ELECTRONICS



JAPAN INTEGRATED CIRCUITS

SOURCE: ELECTRONICS

NORMALITY SHOULD RETURN TO THE DRAM MARKET ABOUT MIDYEAR

similar 5% increase to $3.5 billion.

Other parts of the component business will display similar percentage drops in growth rate, according to the survey, but shipments are considerably less than those of ICs, so the effect on totals won't be as dramatic. Shipments of passives are forecast to rise 3.5%, to $19.1 billion, compared with 1988's 7% and $18.5 billion. Similarly, hybrid and modular component growth rates will slump to 5%, to $1.9 billion, after chalking up a 18% increase last year, to $1.8 billion.

Growth will stop in the tube business, with shipments worth 1% less than last year's $2.9 billion, a 10.5% increase over the year before. Expected to do almost as well as last year are optoelectronic devices, rising 12% to $2.6 billion. In 1988 the increase was 16%, to $2.3 billion.

Normality should return to the dynamic-random-access-memory market about the middle of the year. Last year started with a shortage of 256-Kbit and 1-Mbit parts as companies switching capacity to 1-Mbit DRAMs lost 256-Kbit output faster than they could ramp up production of the bigger chips. On top of that, they found the larger-capacity parts difficult to make, but their growing pains will soon be just painful memories.

Still, that is why much of the explosive growth in sales last year—an eye-popping 77%, to $2.1 billion—came from higher prices rather than a big jump in units. But 1989 growth, forecast to be 16%, will come from more unit sales. Prices will stabilize, then fall, as production lines installed last year started coming on line in the second half with resulting yield increases.

In static random-access memories, where the hot product will be 256-Kbit biCMOS emitter-coupled-logic-compatible parts with speeds of 25 ns or better, the growth rate will dip to 21% and $1.2 billion from last year's 44% for $986 million. Slower CMOS devices with four transistors per cell and full CMOS with six transistors per cell are also hitting the market. At the low-density end, 16-Kbit SRAMs for products such as compact disks can be shoehorned into the controller chip, and it won't be too long before 64 Kbits will fit too. So far, though, demand for high-speed 16- and 64-Kbit chips is still there.

Read-only-memory shipments will increase 18% to $2 billion, a considerable comedown from last year's 57%. Electrically-erasable programmable ROMs are one of the question marks, as they have been for some time. Officials at Hitachi, Toshiba, and other companies say that they must make 64-Kbit flash EEPROMs for smart cards, but for other applications the devices could be too expensive and offer capacity that is too low.

In microprocessors and microcomputers, 32-bit processors get the most attention, though demand is greatest for 8-bit chips, says Kuzuo Kimbara, group executive at Hitachi's Electron Devices Group. These are followed in order of sales by 4- and 16-bit, with 32-bit business still very small. The most visible 32-bit chips are Intel's and Motorola's in personal computers, terminals, and work stations.

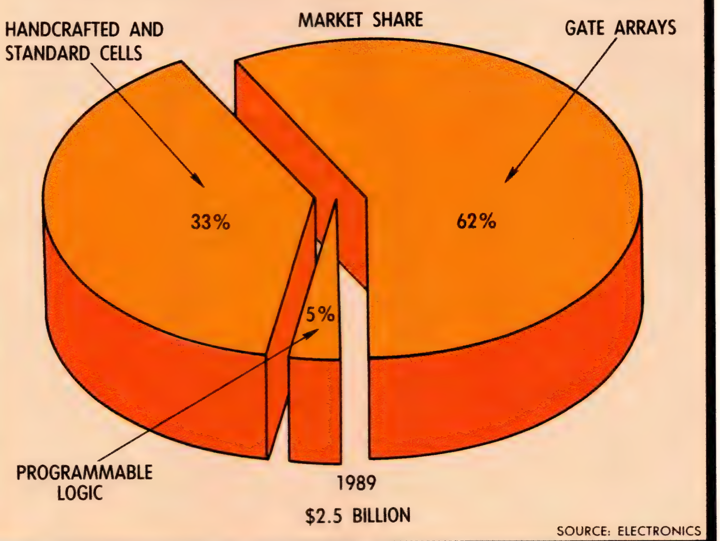
As always, the lion's share of the Japanese linear IC market is for consumer applications. But growth is slowing down as more digital processing creeps into audio gear, VCRs, and TV sets. So the survey indicates that 1989 should actually register a 1% decline from last year's meager 1% uptick, to $1.6 billion.

The tube market looks worse this year than last, when sales rose only 10%. There will be no growth in TV picture tubes or microwave tubes, and image-sensing, light-sensing, and power tubes show declines.

Among area image sensors, which are forecast to take a 5% drop from last year's total of $104 million, charge-coupled-devices and MOS types for camcorders and video cameras have completely taken over the market, except for a small number of high-resolution or high-sensitivity camera tubes for broadcast and professional or special applications. Growth of imagers is now dependent on the growth of camcorders and video cameras.

Sales of another type of array product, liquid-crystal-display drivers, are rising so rapidly that manufacturers can't keep up. The reason is the proliferation of LCD color TVs, monochrome laptop computers (with color versions coming out this year), and laptop computers and other equipment with plasma displays and electroluminescent displays. Not coincidentally, manufacturers of the panels are enjoying increasing sales as are the makers of equipment that is needed to fabricate the panels. ☐

JAPAN CUSTOM/SEMICUSTOM ICs



SOURCE: ELECTRONICS

JAPAN COMPONENTS

	(millions of dollars) 1987	1988	1989
Semiconductors, total	**15,652**	**19,212**	**21,190**
Discrete, total	2,815	2,998	3,187
Diodes, total	875	915	1,027
Microwave (above 1 GHz)	31	32	32
Rectifiers	423	458	561
Signal (less than 100 mA)	226	225	229
Varactor	99	101	105
Zener	96	99	100
Protection devices	88	94	98
Thyristors	178	202	208
Transistors, total	1,674	1,787	1,854
Bipolar, total	1,394	1,463	1,497
Power (1 W or more)	660	700	717
Small-signal	734	763	780
Field-effect	161	175	185
Power (1 W or more)	78	87	93
Small-signal	83	88	92
Gallium arsenide	11	13	15
Rf & microwave	108	136	157
Integrated circuits, total	12,837	16,214	18,003
Custom & semicustom, total	1,871	2,303	2,584
Custom (compiled, standard-cell, handcrafted)	629	756	833
Gate arrays	1,134	1,417	1,605
Programmable logic devices	108	130	146
Linear ICs, total	3,283	3,459	3,607
Communications (codecs, etc.)	230	251	279
Consumer-product ICs	1,590	1,615	1,600
Interface (buffers, decoders, drivers, etc.)	692	743	782
Op amps (monolithic only)	383	405	424
Voltage references and regulators	183	197	210
Other	205	248	312
Memories, total	2,926	4,732	5,565
Random-access memory, total	1,867	3,072	3,604
Dynamic RAM	1,180	2,086	2,412
Static RAM	687	986	1,192
Read-only memory	1,059	1,659	1,962
Microprocessors and microcomputers	1,664	2,072	2,369
Special-purpose processors	1,375	1,739	1,922
Standard logic families, total	1,718	1,909	1,956
BiCMOS	176	226	266
Bipolar	1,264	1,336	1,292
CMOS	278	347	398
Hybrid & modular components, total	**1,510**	**1,777**	**1,861**
Optoelectronic devices	**1,996**	**2,312**	**2,585**
Discrete light-emitting diodes	388	427	454
Imaging arrays (CCD, diode, transistor)	64	78	90
Laser diodes	140	164	186
Optically coupled isolators	50	55	60
Photoconductive cells (light-dependent resistors)	24	26	28
Photodiodes & phototransistors	41	46	51
Readouts	1,098	1,289	1,486
Liquid-crystal displays	529	623	710
Other readouts (vacuum-fluorescent, etc.)	569	666	776
Photovoltaic cells	191	227	230
Tubes, total	**2,604**	**2,878**	**2,862**
Cathode-ray (except TV)	645	902	910
Image-sensing	111	104	99
Light-sensing	120	120	112
Power tubes	105	104	102
Microwave (magnetrons, klystrons, etc.)	257	263	251
TV picture, total	1,366	1,385	1,388
Color	1,357	1,382	1,385
Monochrome	9	3	3
Passive & mechanical, total	**17,237**	**18,470**	**19,114**
Capacitors, total	2,817	2,965	2,672
Fixed	2,760	2,906	2,617
Variable	57	59	55
Connectors, plugs, & sockets	1,806	2,000	2,160
Microwave components	357	335	316
Printed circuits & interconnection systems	3,165	3,588	4,047
Quartz crystals (including mounts & ovens)	456	521	601
Relays (for communication and electronic equipment)	284	312	324
Resistors, total	1,606	1,662	1,629
Fixed	645	686	663
Networks	101	107	112
Potentiometers & trimmers	860	869	854
Composition	832	842	827
Wirewound	28	27	27
Servos, synchros, & resolvers	432	480	504
Switches & keyboards	1,475	1,583	1,663
Transformers, chokes, & coils	2,301	2,330	2,398
Wire & cable, total	2,538	2,694	2,800
Fiber-optic	36	36	41
Coaxial	115	134	146
All other	2,387	2,524	2,613
COMPONENTS, TOTAL	**38,999**	**44,649**	**47,612**

All figures in current U.S. dollars.
Exchange rate: 116 yen to $1

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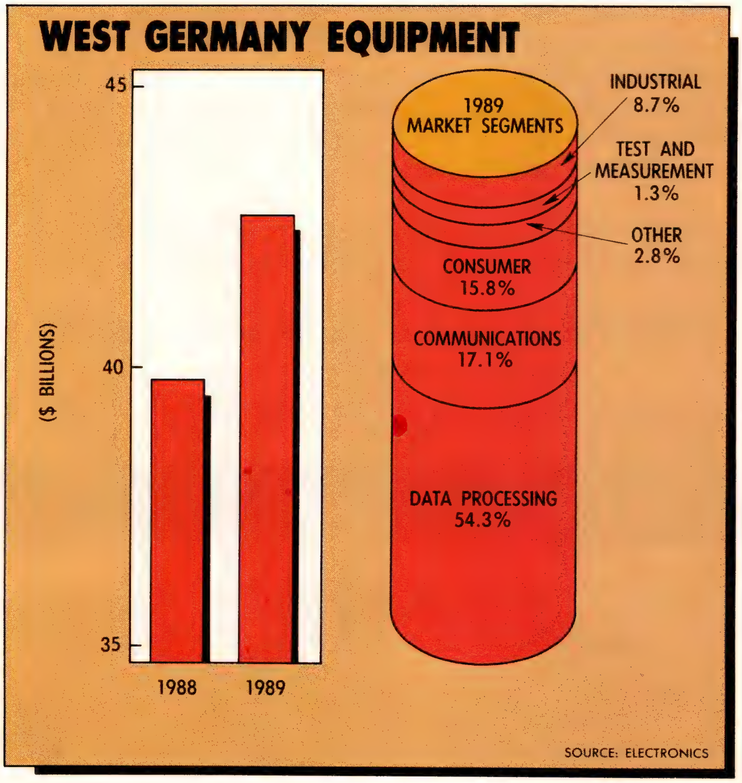
WEST GERMANY

SOLID '89 FOLLOWS A SURPRISING '88

Barring another year of pleasant surprises, West German equipment and components markets won't show as much bustle in 1989 as they did in 1988. Last year, Europe's largest economy was pegged to expand no more than 1%, which had forecasters convinced the country's electronics markets could do no better than 5% growth. Instead, the economy shrugged off the October 1987 stock market crash and strode ahead for a 3.5% gain. The equipment market, in turn, notched growth of 9%, according to the *Electronics* survey, and components climbed by 7%.

Will 1989 see a repeat of the solid 1988 performance? Hardly, say leading economists. Most foresee 2% to 2.5% growth in gross national product. Indirect taxes of $5 billion this year will dampen private consumption, says Manfred Beinder, chief economist at Stuttgart-based Standard Elektrik Lorenz AG, and government spending as well as construction activity will slow down.

As a result, the electronics industry should ease off to 5% growth overall this year, the survey shows. That breaks down into a 6% gain in equipment markets, which will rise to $41.2 billion from last year's $38.7 billion; and a 4% increase for components, scoring $7.4 billion against last year's $7.1 billion.



SOURCE: ELECTRONICS

Among the equipment categories, some consumer electronics segments will suffer drastic declines as the category overall rises just 2% to $6.7 billion. Growth in communications equipment will be essentially flat, with just $6.37 billion in sales against $6.36 billion last year. Computers, though, will once again enjoy above-average growth, equaling last year's 7% rise to achieve $10 billion.

In components, markets will be lukewarm pretty much across the board. Semiconductors overall will rise 4% to $2.4 billion coming off a 14% gain in 1988, while the biggest segment in this category—integrated circuits—will increase 5% to $1.9 billion, against a 17% boost last year.

Consumer-electronics suppliers faced with scant 2% growth in 1989 may wistfully remember 1988 as "a minor boom year," laments Johanna von Ronai-Horvath, a market analyst at Nokia Graetz GmbH, the Finnish Nokia group's German subsidiary in Pforzheim. This was especially true for television makers. The strong economy, the Olympic Games, and the European Soccer Championship helped to push the large TV market to $2.1 billion in 1988, a rise of 5%.

But even in the slow year ahead there should be some fast steppers. Camcorders, for example, are projected to sell at a brisk 20%, becoming a $300 million market. Good growth is also in store for microwave ovens—30%. Demand for big-ticket items like stereo equipment and TV sets, however, will rise moderately at best and decline at worst. The industry mainstay, color TV, for example, will dip 2% to $2.1 billion.

Technologically, the entertainment sector in 1989 will be characterized by a continuing penetration of digital TV sets and cable and satellite TV into the market. Digital TV is a domain primarily for large sets, those with screens from 25 to 28 in., an equipment category for which sales are traditionally slow. Not until medium-size sets go digital will this technique affect overall sales in any significant way.

In good times or bad, the computer sector always has something going for it—the need to streamline industrial and office operations; the effort to offset rising labor costs; the rise of new markets, like word processing and minicomputers; the use of more data handling in communications. So it's little wonder that West Germany's computer market just keeps rolling along. This year, the survey shows, markets for data-processing gear of all sorts should move up smartly to $17.3 billion, growing at a rate about a percentage point lower than 1988's 8%. "If anything, business may be even better than last year," says Jochen Rössner, senior marketing specialist at Unisys Deutschland GmbH in Sulzbach. Computer hardware should grow at 7% also, to $10 billion, *Electronics* projects, and software will zoom 17% to $5.5 billion.

Certain trends are clear. One is that sales of mainframes and large central-processing units are slowing, a result of decentralization of computing operations. The *Electronics* survey predicts that mainframe sales will go up 6% this year to $3.6 billion. Personal computer sales should rise faster, by 9% to $1.5 billion, and microcomputers even faster, by 13% to $1.4 billion.

In the PC arena, Rössner sees high-end systems based on Intel Corp.'s 80386 and comparable microprocessors from other vendors doing exceptionally well. He forecasts sales increases of better than 20% this year, with the push coming from two directions. One is desktop publishing and the other is the need to solve complex computer-aided design problems efficiently.

West Germany's communications equipment sector went into

WEST GERMANY EQUIPMENT

	(millions of dollars) 1987	1988	1989
Consumer electronics, total	**6,235**	**6,551**	**6,645**
Audio equipment, total	2,359	2,449	2,426
Car	469	492	516
Compact-disk players	221	314	322
Phonographs & radio-phonographs	56	59	61
Radios (table, clock, & portable)	188	181	171
Radio/recorder combinations	438	463	474
Stereo equipment	796	754	713
Tape recorders & players	191	186	169
Home video equipment, total	1,307	1,418	1,475
Camcorders	200	250	300
Cassette players & recorders	1,107	1,168	1,175
Television receivers, total	2,078	2,172	2,131
Color	2,035	2,132	2,100
Monochrome	43	40	31
Other consumer products, total	491	512	613
Calculators (personal and professional)	81	75	72
Musical instruments	88	84	81
Microwave ovens	322	353	460
Communications equipment, total	**5,829**	**6,363**	**6,368**
Data communications equipment	194	213	231
Facsimile terminals	197	372	403
Fiber-optic systems	106	125	156
Intercom systems	53	50	44
Navigation aids (except radar)	44	51	54
Paging systems, public & private	63	69	78
Radar (air, land, & marine)	272	287	287
Radio, total	662	754	733
Broadcast equipment	96	109	106
Land-mobile (mobile & base stations)	253	325	375
Microwave systems	250	250	189
Satellite earth stations	63	70	63
Telecommunications equipment, total	3,940	4,020	4,023
Customer-premise equipment	350	350	344
Telephone & data-switching systems, private	1,050	1,044	1,069
Telephone & data-switching systems, public	969	1,188	1,313
Transmission & carrier equipment	1,571	1,438	1,297
Television, total	298	422	359
Broadcast	70	69	72
CATV (except cables)	78	181	106
CCTV (including educational, industrial, & medical)	150	172	181
Data processing & office equipment, total	**15,018**	**16,164**	**17,295**
Computer systems, total	8,738	9,334	9,963
Personal computers (under $5,000)	1,250	1,375	1,500
Microcomputers ($5,000 to $20,000)	1,125	1,250	1,406
Minicomputers ($20,000 to $100,000)	2,313	2,469	2,563
Superminicomputers ($100,000 to $400,000)	720	766	812
Mainframe computers ($400,000 to $5 million)	3,280	3,421	3,626
Supercomputers and minisupercomputers	50	53	56
Data-input peripherals	453	491	529
Data-output peripherals	1,719	1,906	2,063
Data-storage subsystems	1,563	1,750	2,000
Data terminals	1,875	2,000	2,094
Electronic office equipment, total	670	683	646
Copiers	407	433	427
Electronic typewriters	125	125	119
Word-processing systems	138	125	100
Software, total	**4,000**	**4,688**	**5,500**
Industrial equipment, total	**2,923**	**3,265**	**3,472**
Inspection systems (ir & X-ray)	47	50	53
Machine-tool controls (including numerical-control systems)	296	349	376
Motor controls (speed, torque)	392	463	499
Process-control equipment (including loggers, consoles, etc.)	1,500	1,590	1,669
Programmable controllers	688	813	875
Semiconductor production equipment, total	**138**	**147**	**161**
Power supplies, noncaptive, total	**256**	**263**	**273**
Bench & lab	27	28	29
Industrial	23	23	24
OEM & modular, total	206	212	220
Linear	56	53	48
Switching	150	159	172
Test & measurement equipment, total	**537**	**545**	**560**
Amplifiers, lab	9	9	8
Analog voltmeters, ammeters, and multimeters	11	10	9
Automatic test equipment, total	154	166	178
Discrete-component testers	4	5	6
IC testers	56	61	66
Pc-board testers	94	100	106
Calibrators & standards, active and passive	6	6	7
Counters, time & frequency	23	23	23
Digital multimeters (including probes & accessories)	34	35	36
Logic analyzers	22	23	23
Microprocessor development systems	38	31	28
Microwave test & measurement instruments	41	43	44
Oscillators	8	9	9
Oscilloscopes	89	83	84
Recorders & plotters (including chart & X-Y types)	48	51	53
Signal generators (pulse, sweep, & function), total	21	22	23
Analog	10	9	9
Synthesized	11	13	14
Spectrum analyzers	33	34	35
CAD/CAE equipment, total	**625**	**750**	**888**
EQUIPMENT, TOTAL	**35,561**	**38,736**	**41,162**

All figures in current U.S. dollars.
Exchange rate: 1.6 marks to $1

1989 with a high level of production and sales, ending 1988 with a market volume of about $6.36 billion, the *Electronics* survey has found. This rise, roughly 9% over 1987 sales, was higher than was predicted 12 months ago. Indeed, "1988 checked in with several percentage points better than we expected," says a market analyst in Siemens' Communications Group.

But the lull originally forecast for 1988 may well hit in 1989; at least, that's what the *Electronics* survey indicates. It puts the market at $6.37 billion, less than 1% above the 1988 level. And although some industry observers think 1989 will bring another surprise, most aren't too optimistic in their forecasts.

Probably the main reason for the slack is that the Bundespost, the country's government-run communications authority, is still in what's considered the predigital age. To be sure, the transition from analog to digital switches and related equipment is under way, "but the big installation volumes will come only in the 1990s," says Beinder, the SEL chief economist.

The outlook for some equipment makers is not all bleak, however. They are enjoying good export business, Beinder says, and at home "the private sector is doing well." This is shown by a continuing strong demand for facsimile terminals and private-branch-exchange systems. Sales of fax equipment this year will rise 8% to $403 million, *Electronics* projects. "Business with air-traffic control gear is not bad either," Beinder adds.

Again in 1989, certain product categories will do well at the expense of others. For example, a declining market for microwave radio equipment will be partly offset by strong sales of fiber-optic communications systems—they'll go from $125 million in 1988 to $156 million this year, a 25% rise, the survey shows. Fiber-optic systems are replacing microwave gear and are increasingly being used in local-area networks.

One product doing fine in terms of market increase is cellular radio equipment. Here, industry watchers expect a spurt of better than 15% in 1989. The real upswing, though, will start in the early 1990s, when Europe begins converting its hodgepodge of mobile cellular phone systems into a single pan-European digital network.

For German components makers, 1989 won't be a great year, but it will be remembered as another one of recovery from the disastrous slump of 1986/87. The *Electronics* survey finds that overall growth in the $7.4 billion components market this year will come to only 4%. That's not much compared with some years and with what other European countries will register in 1989. And it's a dip from the 7% achieved in 1988. But in the long term, the components industry is expected to grow 6% to 7% a year, says Manfred Schmidt, president of Valvo, the Hamburg-based components-producing arm of Philips International NV.

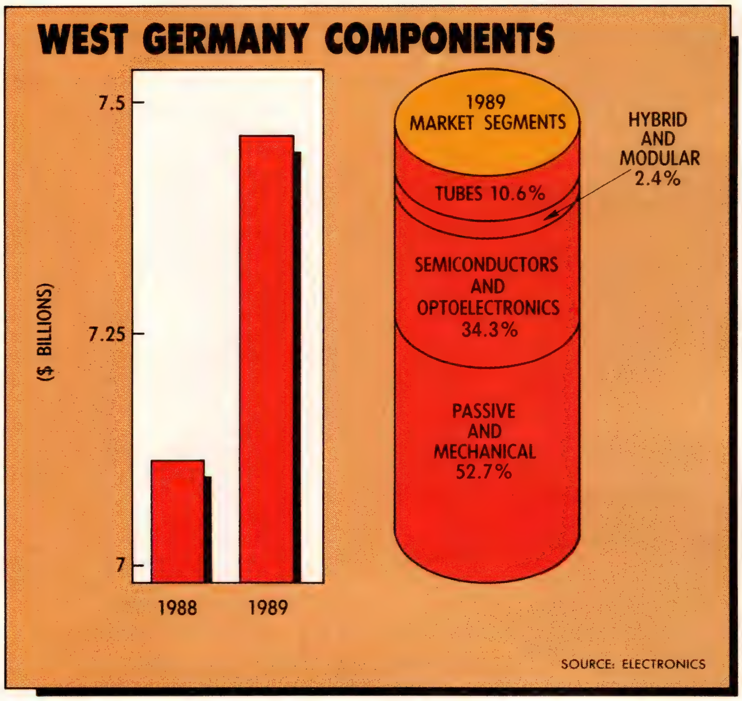
A LULL COULD HIT IN COMMUNICATIONS, YIELDING NO GROWTH

Given Germany's strength in industrial electronics, that sector will come in as the biggest components user, accounting for one quarter of the output. Following hard on its heels is telecommunications, which takes a little under 25% of what the parts market offers.

Although the auto industry accounts for a fairly small components share, it is the fastest-growing customer. For example, in 1987, carmakers bought some $800 million worth of components, 11% more than the previous year. Its demand kept growing at an above-average rate last year and is expected to do so in 1989 as well.

Dominating the components sector by far are passive and electromechanical parts. In 1989, they will account for more than half the market, with semiconductors taking roughly a third and optoelectronic devices and tubes around 10%. In the passive and mechanical parts category, the market for connectors, plugs, and sockets is almost twice that for discrete semiconductors.

Overall, after spectacular growth of 30% and 18% in the years 1984 and 1985, respectively, sales of passive and mechani-



SOURCE: ELECTRONICS

cal components inched up only 1% in 1987 and another 4% last year, to $3.7 billion. This year it should equal that growth rate, rising to $3.9 billion.

Far more exciting for their growth potential are active devices. Hans Weinerth, head of the active components section of West Germany's Association of the Electrotechnical and Electronics Industries, pegs the 1988 rise for this device category at 8%. For 1989, however, Weinerth foresees sales slowing down to a 5% rate.

As for West Germany's performance in semiconductor sales this year, Jan Càlen, marketing director at Motorola Inc.'s Geneva-based European operations, forecasts a rise of 6%. That's a little better than the findings of the *Electronics* survey, which puts growth at just above 4%, up from $2.3 billion in 1988 to $2.40 billion this year.

By and large, the growth in semiconductors is supported by sales of ICs. These, the *Electronics* survey shows, will go up 5% in 1989 to $1.9 billion. That's a slowdown from last year's 17% growth rate, fueled by brisk sales in MOS memories, microcontrollers, application-specific ICs, and bipolar digital circuits, says the association's Weinerth. These same devices should lead growth in 1989, too.

Influencing the integrated-circuit market to no small extent is the way prices for memories go. For these devices, price rises of 100% "are no rarity," Weinerth says. "Since for 1989, an adequate supply is not fully assured, we don't see a short-term price drop coming."

Memories are set to grow 5% to $494 million, a big fall-off from 1988's 63% growth rate. The best performers are read-only memories, rising 10% to $138 million; random-access memories will rise a scant 2% to $325 million.

The biggest IC user next year will again be the data processing sector, according to Siemens market researchers, accounting for about 27% of total consumption. Next in line is industrial electronics, at 20%, and the entertainment and communications equipment sectors, with 19% and 15%, respectively. The car industry accounts for another 13% and the remaining 5% will go elsewhere.

Invariably, when German electronics executives discuss their chip markets, the subject quickly turns to the extent of Europe's domination by U. S. and Japanese suppliers. In 1987, "Western Europe found itself exposed to a $1.78 billion flow of IC imports from the U. S. alone, and on top of that came deliveries from Japan worth $940 million," says Jürgen Knorr, chairman of West Germany's Electronic Component Manufacturers Association. Western Europe's own chip production was $2.4 billion that year, Knorr says. At the same time, Europe exported only $500 million worth of chips to these countries. This must change, Knorr says. In fact, "the European industry has made it its goal to correct this imbalance."

To reach that goal, European companies have embarked on a number of strategic catch-up programs. One is the Mega project, which has given Siemens and Philips a capability in high-density memories and a chance to pull even with the Japanese in the field. Another is the Joint European Submicron Silicon project, which aims at putting the European chip industry on a par with that of Japan and the U. S. by the mid-1990s and helping it to compete with them in memories and logic devices. □

WEST GERMANY COMPONENTS

	(millions of dollars) 1987	1988	1989
Semiconductors, total	**2,002**	**2,286**	**2,387**
Discrete, total	480	503	509
Diodes, total	175	169	168
Microwave (above 1 GHz)	8	8	9
Rectifiers	90	90	89
Signal (less than 100 mA)	31	28	27
Varactor	10	10	11
Zener	36	33	32
Thyristors	89	88	82
Transistors, total	216	246	259
Bipolar, total	185	210	219
Power (1 W or more)	97	119	125
Small-signal	88	91	94
Field-effect, total	26	30	33
Power (1 W or more)	18	22	25
Small-signal	8	8	8
Rf & microwave	5	6	7
Integrated circuits, total	1,522	1,783	1,878
Custom & semicustom	231	256	269
Linear ICs, total	400	382	383
Communications (codecs, etc.)	89	91	91
Consumer-product ICs	189	181	178
Interface (buffers, decoders, drivers, etc.)	47	42	46
Op amps (monolithic only)	44	45	46
Voltage references and regulators	29	21	20
Timers	2	2	2
Memories, total	287	469	494
Application-specific (including video)	6	25	31
Random-access memory	184	319	325
Read-only memory	97	125	138
Microprocessors and microcomputers	278	344	381
Standard logic families, total	326	332	351
Bipolar	213	194	188
CMOS	113	138	163
Hybrid & modular components, total	**163**	**170**	**178**
Optoelectronic devices, total	**124**	**131**	**134**
Discrete light-emitting diodes	29	31	31
Laser diodes	3	4	5
Optically coupled isolators	24	25	25
Photoconductive cells (light-dependent resistors)	20	21	21
Photodiodes & phototransistors	21	23	24
Photovoltaic cells	5	6	6
Readouts (LCD, LED, fluorescent, etc.)	22	21	22
Tubes, total	**766**	**771**	**778**
Cathode-ray (except TV)	47	50	54
Image-sensing	50	52	53
Light-sensing	13	13	13
Power tubes (magnetrons, klystrons, etc.)	94	94	96
TV picture, total	562	562	562
Color	556	556	556
Monochrome	6	6	6
Passive & mechanical, total	**3,560**	**3,713**	**3,876**
Capacitors, total	544	557	566
Fixed	528	541	550
Variable	16	16	16
Connectors, plugs, & sockets	906	938	969
Filters, networks, & delay lines	81	88	95
Loudspeakers (OEM)	128	137	144
Printed circuits & interconnection systems	844	894	963
Quartz crystals (including mounts & ovens)	72	78	82
Relays (for communications and electronic equipment)	250	265	283
Resistors, total	247	248	246
Fixed	147	147	150
Networks	19	20	21
Potentiometers & trimmers	81	81	75
Switches & keyboards	225	236	250
Transformers, chokes, & coils	263	272	278
COMPONENTS, TOTAL	**6,615**	**7,071**	**7,353**

All figures in current U.S. dollars.

Exchange rate: 1.6 marks to $1

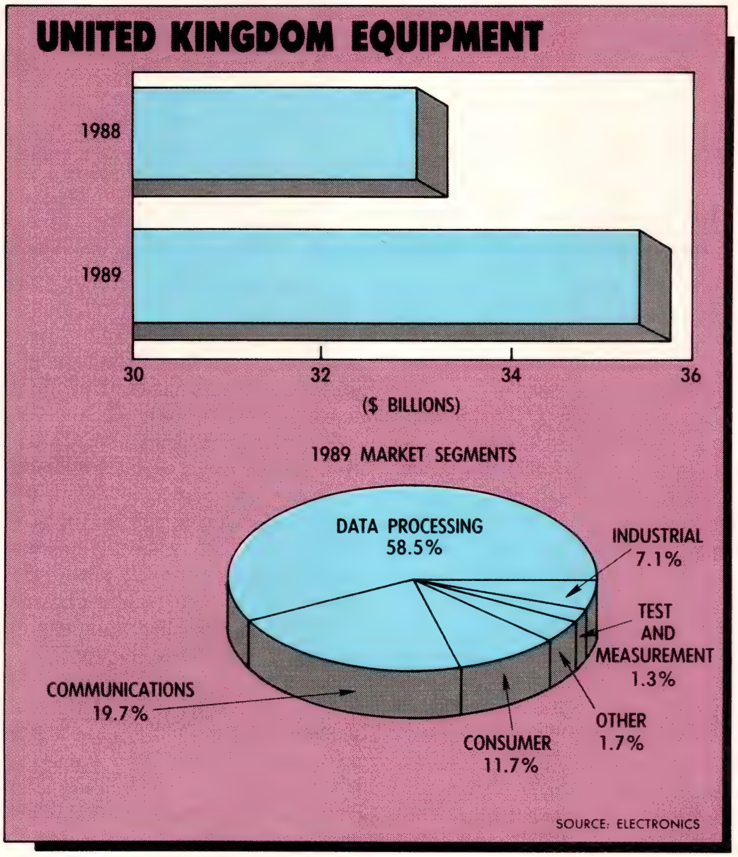
UNITED KINGDOM

MOST MARKETS STILL GOING STRONG

Britain's electronics markets figure to remain Beefeater solid for the second year running. The *Electronics* consensus survey points to equipment markets totaling $31.6 billion in 1989, up 8% over 1988, when sales rose 9%. Components should climb 9% to $5.8 billion, against a 10% rise last year.

Despite a sharp downturn in personal computers, the pace-setting equipment sector will be data-processing gear: *Electronics* projects sales of computers, peripherals, and allied office-automation gear rising a strong 7%, a bit of a slide from last year's lusty 11% hike. Sales will climb to $11.4 billion from $10.6 billion. Suppliers of communications gear should see a small uptick in their growth rate—from 6.5% in 1988 to 7% in 1989—bringing sales to $7 billion. A modest 5% growth for consumer electronics will carry the sector just above the $4 billion mark. And makers of test and measurement hardware will have a lot to cheer about: the survey predicts a 15% surge to $474 million.

In components, the fastest-paced sector should be integrated circuits, rising 16% to $1.9 billion on the heels of a 22% gain in 1988. This performance should carry the semiconductor category overall to a 15% year, with $2.2 billion in sales, a tad below last year's 19% growth rate.



SOURCE: ELECTRONICS

Still, some industry watchers fret that the good times may not last. There's a scent of inflation in Great Britain's economic atmosphere, and just a sniff is all it takes for Margaret Thatcher's government to apply the brakes to the economy. As goes the economy, so go the electronics markets. At least one market researcher—Ken Wilson, publisher of the *Yearbook of World Electronics* (formerly the Mackintosh Yearbook)—is convinced that overall growth will total only 4% in real terms. A four-year cycle crested in 1988, he contends, and a slide will continue through 1991, then bottom out and turn upward in 1992.

Another industry concern is that foreign companies are doing too well in UK markets. In fact, the trade balance for electronics remains firmly in deficit. As a result, some major manufacturers are pushing services along with hardware. Sales of services in 1988 will account for more than $19.4 billion for companies such as Racal plc and GEC plc, says Peter Sachs, director of the Electronic Engineering Association.

But despite such qualms, it appears that most markets will keep perking, for the near term at least. Government statistics confirm that more money is spent in the UK on data processing and computer equipment than on any other electronic industry product. Of the $11.4 billion sales total expected for the sector in 1989, *Electronics* projects that computer systems will account for $7.9 billion, a 10% rise over 1988. Last year marked a 17% gain.

There will be ups and downs, including a major swing: last year, personal computers led the list for growth, ringing up a gain of nearly 39% and sales of $1.6 billion. But 1988 was marked by price cutting as a small horde of new competitors tried to buy market share. Now almost every business that wants PCs has them, and the market should plummet to only 2% growth, with sales of $1.7 billion.

However, larger microcomputers that can run complex applications in networks linking machines around the country seem set to star. Sales here should surge 22% to $681 million, a gain that is identical to last year's.

Both micros and minicomputers—which are set for a 13% surge to just over $1 billion—are getting a boost from telecommunications, as the national telephone companies introduce digital switches and head toward full integrated services digital networks. Companies that in the past would have run a mainframe at the main office and fed it with data packs from branch offices are installing microcomputer-based servers to tie smaller machines together. For example, a Scottish newspaper group this year will spend about a million dollars to replace a three-year-old mainframe with such a Unix-based system.

Despite the trend toward networking with small machines, mainframe sales are holding their own. The forecast shows them matching last year's 11% growth rate for total sales of $3.6 billion in 1989.

The telecom markets themselves will show steady, rather than spectacular, growth again this year, rising 7% to $7 billion overall. Most of the money will come from the two national telecommunications network operators, British Telecom plc and Mercury Communications plc. Other big spenders are the operators of national cellular telephone networks, Racal Telecom plc and the BT subsidiary Cellnet. This quartet is expected to spend around $1.4 billion on digital central office switching systems;

UNITED KINGDOM EQUIPMENT

	(millions of dollars) 1987	1988	1989
Consumer electronics, total	**3,989**	**4,160**	**4,360**
Audio equipment, total	1,320	1,410	1,517
Car	200	211	223
Compact-disk players	187	250	334
Phonographs & radio-phonographs	185	185	185
Radios (table, clock, & portable)	67	63	59
Radio/recorder combinations	198	209	214
Stereo equipment	309	307	305
Tape recorders & players	174	185	197
Home video equipment, total	911	982	1,061
Camcorders	87	111	142
Cassette players & recorders	823	870	918
Television receivers, total	1,117	1,135	1,153
Color	1,082	1,104	1,126
Monochrome	35	31	27
Other consumer products, total	642	634	630
Calculators (personal and professional)	67	59	53
Musical instruments	125	140	157
Microwave ovens	450	435	420
Communications equipment, total	**6,142**	**6,542**	**7,005**
Data communications equipment	176	191	207
Facsimile terminals	300	402	540
Fiber-optic systems	46	60	78
Intercom systems	25	27	30
Navigation aids (except radar)	520	535	550
Paging systems, public & private	57	65	73
Radar (air, land, & marine)	1,073	1,103	1,133
Radio, total	942	1,051	1,172
Broadcast equipment	109	113	117
Land-mobile (mobile & base stations)	744	838	944
Microwave systems	59	65	71
Satellite earth stations	30	35	40
Telecommunications equipment, total	2,799	2,888	2,983
Customer-premise equipment	408	414	421
Telephone & data-switching systems, private	389	372	355
Telephone & data-switching systems, public	1,357	1,443	1,534
Transmission & carrier equipment	645	659	673
Television equipment, total	204	220	239
Broadcast	100	102	104
CATV (except cables)	63	74	87
CCTV (including educational, industrial, & medical)	41	44	48
Data processing & office equipment, total	**9,602**	**10,632**	**11,352**
Computer systems, total	6,216	7,257	7,949
Personal computers (under $5,000)	1,180	1,645	1,684
Microcomputers ($5,000 to $20,000)	455	557	681
Minicomputers ($20,000 to $100,000)	851	962	1,088
Superminicomputers ($100,000 to $400,000)	794	840	889
Mainframe computers ($400,000 to $5 million)	2,901	3,222	3,580
Supercomputers and minisupercomputers	35	31	27
Data-input peripherals	167	178	190
Data-output peripherals	666	703	742
Data-storage subsystems	1,031	1,119	1,215
Data terminals	708	602	512
Electronic office equipment, total	814	773	744
Copiers	522	525	529
Electronic typewriters	209	191	175
Word-processing systems	83	57	40
Software, total	**4,995**	**5,550**	**6,167**
Industrial equipment, total	**1,382**	**1,523**	**1,648**
Inspection systems (ir & X-ray)	9	9	10
Machine-tool controls (including numerical-control systems)	54	69	74
Motor controls (speed, torque)	237	249	262
Process-control equipment (including loggers, consoles, etc.)	919	998	1,084
Programmable controllers	163	198	218
Semiconductor production equipment, total	**47**	**48**	**49**
Power supplies, noncaptive, total	**133**	**138**	**144**
Bench & lab	13	13	14
Industrial	31	32	33
OEM & modular, total	90	93	97
Linear	31	32	33
Switching	59	61	64
Test & measurement equipment, total	**374**	**414**	**474**
Amplifiers, lab	2	2	2
Analog voltmeters, ammeters, and multimeters	15	14	13
Automatic test equipment, total	78	94	114
Discrete-component testers	4	4	4
IC testers	30	31	31
Pc-board testers	44	59	79
Calibrators & standards, active and passive	4	4	4
Counters, time & frequency	26	26	28
Digital multimeters (including probes & accessories)	23	24	25
Logic analyzers	14	14	15
Microprocessor development systems	37	41	45
Microwave test & measurement instruments	19	34	60
Oscillators	4	4	4
Oscilloscopes	55	57	59
Recorders & plotters (including chart & X-Y types)	39	41	43
Signal generators (pulse, sweep, & function), total	34	33	34
Analog	17	13	10
Synthesized	17	20	24
Spectrum analyzers	24	26	28
CAD/CAE equipment, total	**204**	**294**	**424**
EQUIPMENT, TOTAL	**26,868**	**29,301**	**31,623**

All figures in current U.S. dollars.
Exchange rate: $1.85 to 1 pound

their major suppliers are Ericsson Ltd. and Motorola Ltd.

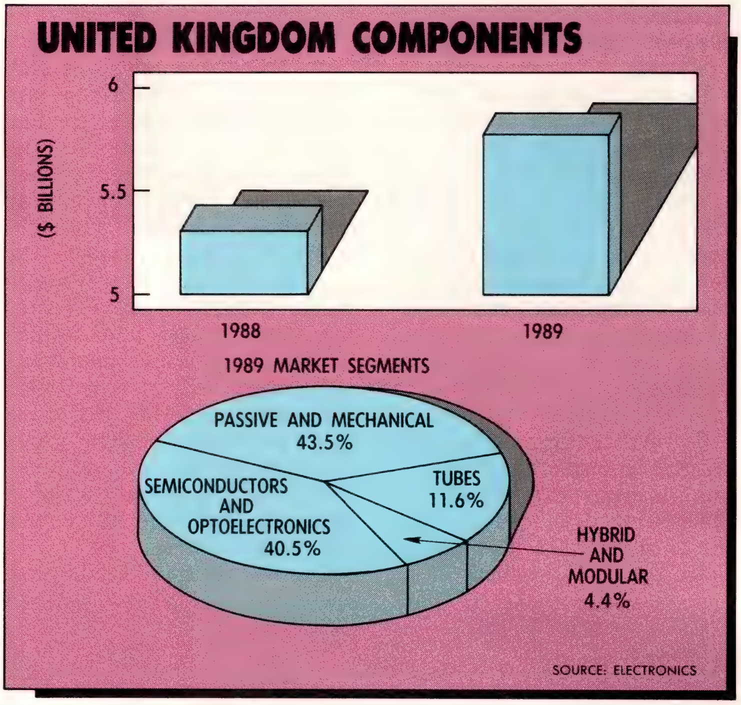
The high rate of spending on digital switches and other public network equipment such as fiber-optic transmission systems may not last much longer, though. John Hooley, a marketing executive at GEC Plessey Telecommunications Ltd. (GPT), says that spending is at a peak right now, and may have just two or three years to run at its present levels.

As for private exchanges, business is forecast to decline as the market becomes saturated. At $372 million in 1988, the sector was down by some 4% on 1987 markets, and it's set to fall another 5%, to $355 million.

The bright spot remains mobile communications, with new cellular services going on line in 1991. This year will see the beginning of trials and developments of these nets, which will operate to new pan-European standards, and they should account for around $370 million worth of sales, mostly for Ericsson, Motorola Communications UK, and Orbitel Ltd.

New for 1989 will be digital cordless telephone services, under the generic name Telepoint. Telepoint will allow owners of pocket telephones to use public base stations located in strategic sites. Motorola Communications managing director Don Burns forecasts that by the end of this year, 71,000 pocket phones will have been bought at around $330 each, for a market of more than $18.5 million. Other estimates range as high as 100,000 units.

Yet another new market, opened up by the now virtually total deregulation of telecommunications in the UK, is "off-street" pay phones. GPT's Hooley says sales over the years could total 10 million units; the first products are appearing in department stores at around $450 retail.



SOURCE: ELECTRONICS

ONE BRIGHT SPOT WILL BE CELLULAR MOBILE PHONES

Britain's consumer-electronics suppliers went into the New Year with record sales for video and some audio equipment. Some 4.5 million color television sets and 2.4 million video-cassette recorders were sold in 1988, says Stephen Michaelis of JVC UK Ltd., chairman of the statistics committee of the British Radio and Electronic Equipment Manufacturers' Association. The result: a 7% uptick for the audio sector to $1.2 billion and an 8% rise for home video (VCRs and camcorders) to $982 million, the *Electronics* survey shows.

And this solid growth should continue. *Electronics* spots the audio market growing another 8% to $1.5 billion and the video 8% to just over a billion. These totals yank the consumer sector overall to $4.4 billion, a 5% gain. The profile of the market is changing as new equipment takes the place of traditional items on the consumer's "wish list." For example, color TV is holding at 2% growth and VCRs hovering at 6%; but camcorders will soar 28% to $142 million. Upcoming will be a raft of satellite-TV receivers, domestic facsimile terminals, and pocket computers.

Meanwhile, test-equipment makers should flourish in the UK this year, with 15% growth to $474 million. The stellar performer, according to the survey, will be microwave test equipment, growing 77% to $60 million. Chalk up the high interest to government initiatives during 1988, including the deregulation of television and radio broadcasting and the licensing of business satellite operators.

For automatic test gear, too, the market looks strong: the survey predicts growth of 21% to $114 million, paced by a 34% surge for printed-circuit-board testers. That category will hit $79 million, up from $59 million.

Back in the factories and laboratories of the UK, instrument makers are expecting demand for their products to follow a more traditional growth pattern, largely continuing the trend away from analog to digital workbench meters. One major manufacturer expects consumption of low-cost logic analyzers to increase rapidly. The *Electronics* forecast sees demand for these handheld instruments rising to $15 million, a 7% gain. In pc-board testers, opinions vary as to just how much all the demand will be worth in real money. The most optimistic estimates peg almost twice the average determined by *Electronics*.

One marketing manager who specializes in this product area predicts sales of between $37 million and $55 million for civil applications and another $55 million for defense electronics equipment makers. Others are less optimistic: "Volumes will certainly rise in 1989, but prices are falling," says Dave Skingley, marketing manager for Philips Test & Measurement Ltd. "So value growth does not really reflect increasing popularity." He adds that the market is split 50/50 between systems bought for in-circuit and functional testing.

Paced by a surge in computer chips, the UK components market bounced up 10% last year to reach $5.3 billion, an all-time high. Especially fevered was the semiconductor sector, which rose 19% to $1.9 billion. Its major subcategory, integrated circuits, rose 22% to $1.6 billion. This year the urge to buy chips figures to slacken, but the sector will remain strong enough. The *Electronics* survey projects components markets in total as growing another 9% to $5.8 billion. Semiconductors overall will mark a 15% rise to $2.2 billion, with ICs posting 16% growth to $1.9 billion.

No one expects the high-flying chip markets to keep gaining altitude forever. The 1988 rate—which some market researchers, like Jim Eastlake of Dataquest UK Ltd. puts at 29%—was fed by the personal computer boom.

Despite this year's predictions of a PC slowdown, some sectors of the IC business will retain high growth rates. Among them are memory devices: random-access memories are set to match last year's 18% growth rate, nabbing $216 million in sales; and read-only memories should equal 1988's 11% gain, for sales of $102 million. Many industry planners expect memory prices to decline a little as a backlog of orders is cleared. As a result, the sales figures represent higher volumes.

Application-specific and custom-design specialists can expect continued increases in the UK market. The forecast shows sales rising 34% for the second year in a row, to $360 million. Indeed, the UK is proving particularly fruitful for custom and customer-designed ICs. As design and simulation techniques become more sophisticated, allowing easier, faster, and less costly access to advanced semiconductor technology, a myriad of new businesses are starting up. Some are small firms founded to exploit a clever design, others are special-project divisions of large corporations.

Also helping to stimulate UK semiconductor markets are a series of new projects including cordless public telephones, satellite-TV broadcasting direct to domestic antennas, and the exploitation of the 30-GHz radio frequency spectrum. Satellite-TV reception and millimeter-wavelength microwave systems may also bring a spate of gallium arsenide chips onto the UK market before the end of 1989.

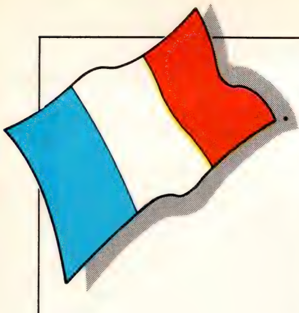
As for passive components, they should rise a modest 5% this year to reach $2.5 billion. Quartz crystals and variable capacitors show up best, both growing 9% to reach $36 million and $12 million, respectively. Pc-board sales are scheduled to rise 8% to $829 million, inching past last year's 7% gain. □

UNITED KINGDOM COMPONENTS

	(millions of dollars)		
	1987	**1988**	**1989**
Semiconductors, total	**1,608**	**1,916**	**2,197**
Discrete, total	265	284	302
Diodes, total	109	116	125
Microwave (above 1 GHz)	9	10	11
Rectifiers	59	64	69
Signal (less than 100 mA)	31	31	32
Varactor	1	2	4
Zener	9	9	9
Thyristors	25	26	27
Transistors, total	131	142	150
Bipolar, total	103	111	117
Power (1 W or more)	57	63	69
Small-signal	46	48	48
Field-effect, total	12	13	14
Power (1 W or more)	7	8	8
Small-signal	5	5	6
Rf & microwave	16	18	19
Integrated circuits, total	1,343	1,632	1,895
Custom & semicustom	200	268	360
Linear ICs, total	258	266	281
Communications (codecs, etc.)	56	63	71
Consumer-product ICs	93	104	116
Interface (buffers, decoders, drivers, etc.)	28	31	35
Op amps (monolithic only)	48	33	22
Voltage references and regulators	17	18	19
Timers	16	17	18
Memories, total	270	312	361
Application-specific (including video)	32	37	43
Random-access memory	155	183	216
Read-only memory	83	92	102
Microprocessors and microcomputers	183	285	313
Standard logic families, total	432	501	580
Bipolar	210	217	217
CMOS	222	284	363
Hybrid & modular components, total	**212**	**233**	**256**
Optoelectronic devices, total	**106**	**118**	**127**
Discrete light-emitting diodes	15	14	13
Laser diodes	10	12	13
Optically coupled isolators	11	12	13
Photoconductive cells (light-dependent resistors)	4	4	4
Photodiodes & phototransistors	4	5	6
Photovoltaic cells	14	15	16
Readouts (LCD, LED, fluorescent, etc.)	48	56	62
Tubes, total	**597**	**633**	**671**
Cathode-ray (except TV)	75	80	85
Image-sensing	46	43	39
Light-sensing	3	3	3
Power tubes (magnetrons, klystrons, etc.)	106	110	114
TV picture, total	367	397	430
Color	363	393	426
Monochrome	4	4	4
Passive & mechanical, total	**2,282**	**2,394**	**2,516**
Capacitors, total	294	318	344
Fixed	284	307	332
Variable	10	11	12
Connectors, plugs, & sockets	448	466	485
Filters, networks, & delay lines	23	23	23
Loudspeakers (OEM)	74	76	78
Printed circuits & interconnection systems	718	771	829
Quartz crystals (including mounts & ovens)	31	33	36
Relays (for communications and electronic equipment)	95	99	102
Resistors, total	197	202	210
Fixed	65	68	72
Networks	39	41	44
Potentiometers & trimmers	93	93	94
Switches & keyboards	163	167	170
Transformers, chokes, & coils	239	239	239
COMPONENTS, TOTAL	**4,805**	**5,294**	**5,767**

All figures in current U.S. dollars.

Exchange rate: $1.85 to 1 pound



FRANCE

OFF THE '88 PACE, BUT HOLDING STEADY

The wheels of commerce will spin a little less speedily in France this year, but the country's electronics markets will nonetheless keep revving at a comfortable level. Equipment makers will see their markets climb 9% overall, from $31.4 billion to $34.2 billion, though this is a little below last year's 11% growth pace. Manufacturers of components won't do quite as well: revenues will grow at only half of last year's 10% rate, inching ahead from $3.9 billion to $4.1 billion, according to the *Electronics* consensus survey.

Economists predict that the French economy should expand 2.7%, a significant slip from the 3.5% registered in 1988. But there's still enough bustle for industrialists to be planning heavy investments, and that's good news for the pace-setting computer sector. Computer systems should rise 9%, racking up $8.8 billion in sales, against last year's 17% climb to $8.08 billion, the survey predicts. Although imported hardware covers a good 40% of the market, French equipment producers will keep their components suppliers in reasonably good shape. The market for semiconductors will rise more than 9% to $1.2 billion, with its main subsegment—integrated circuits—growing 10% to $956 million. Although these are healthy figures, they're not as robust as last year's: a 24% rise for semiconductors overall to $1.1 billion and a 29% leap for ICs to $870 million.

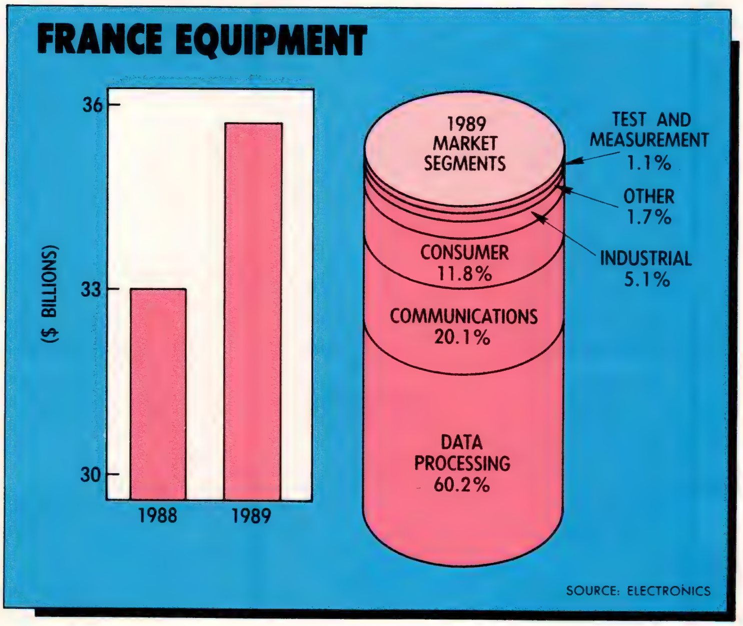
In the other equipment markets, the outlook is for mainly slow, steady growth, the *Electronics* survey predicts. Consumer electronics will rise 3% from $4.1 billion to better than $4.2 billion; communications gear will climb 5% from $6.9 billion to $7.2 billion; industrial equipment will increase 14% from $1.6 billion to $1.8 billion; and test and measurement will rise 7% from $371 million to $397 million. An exception to the slow growth pace is software, equaling last year's 18% rise and moving from $5.2 billion in sales to $6.1 billion.

By and large, French equipment makers are not fazed by the slight growth drop-off in most categories. Their prime concern is how much of their home market they can keep for themselves now and in the years ahead.

In general, "French manufacturers are ready and able to invest in increased production capacity," says Jean Caillot, president of Thomson International SA and of the Groupement des Industries Electroniques (GIEL), the umbrella trade association for the French electronics industry. Caillot is convinced that plant investments ensure a strong year for French equipment markets, but he has a word of warning: "It is unlikely that the French [electronics] industry will be able to profit fully from this market expansion; much of the equipment and components enjoying rapid market growth are imported." The situation could become catastrophic, he says, "if appropriate steps are not taken immediately to increase our competitiveness on a world scale by working together, and to protect the European market by appropriate European Community legislation."

In the $13.8 billion data processing market, small will be beautiful this year: fueled by the 9% growth in computers, the overall sector will rise 9% as well, *Electronics* predicts. Still, this

FRANCE EQUIPMENT



SOURCE: ELECTRONICS

pace is not as robust as 1988's 14% gain to $12.7 billion. The large mainframe segment will mark only tepid growth—a 5% rise to $3.8 billion.

The French market for personal computers is projected to expand 22% to $1.9 billion—much faster growth than in other PC markets around the world, but nowhere near the 50% boom experienced in France last year. Multiuser microsystems, at $897 million, will rise only 7%, less than half the 1988 gain. Much the same story turns up in the $1.3 billion minicomputer market, predicted to rise only 6% after turning in a strong 15% gain in 1988. Superminis will rise just 4% to $846 million while supercomputers and minisupercomputers will grow 9% to $77 million.

"The explosive volatility of the small computer market is extremely sensitive to external economic factors," says Gerard Benbassa, a marketing-management services executive at Groupe Bull in Paris. "Major systems are budgeted well in advance, whereas the decision to buy smaller computers is not generally foreseen on the same time scale, nor with the same rigidity." The conditions that produced the PC boom last year should continue in 1989, Benbassa expects. But he warns that if the economy starts to sag, "it's the small contracts that will take the brunt of the squeeze; the major contracts will generally be carried out as planned."

As for peripherals, they have a strong market no matter whether it's large systems or small that are setting the pace. As a result, the survey projects total sales this year of $4.2 billion, a rise of 10% overall for data-input and -output gear, data-storage systems, and data terminals. Strong growth should continue through 1992, with only minor fluctuations.

Makers of communications gear figure to log about 5% growth this year, a percentage point lower than 1988, when the market came out of a slump. Sales should rise to $7.2 billion, against $6.9 billion last year.

The market forces will realign somewhat, however. Last year, radio equipment sales moved up 11% to $811 million and radar a

FRANCE EQUIPMENT

	(millions of dollars) 1987	1988	1989
Consumer electronics, total	**3,937**	**4,112**	**4,238**
Audio equipment, total	1,323	1,319	1,316
Car	285	294	301
Compact-disk players	77	91	98
Phonographs & radio-phonographs	6	5	5
Radios (table, clock, & portable)	83	66	56
Radio/recorder combinations	206	198	191
Stereo equipment	569	575	584
Tape recorders & players	97	90	81
Home video equipment, total	708	767	804
Camcorders	68	89	95
Cassette players & recorders	640	678	709
Television receivers, total	1,299	1,342	1,363
Color	1,250	1,294	1,319
Monochrome	49	48	44
Other consumer products, total	607	684	755
Calculators (personal and professional)	58	54	52
Musical instruments	54	53	54
Microwave ovens	495	577	649
Communications equipment, total	**6,511**	**6,884**	**7,226**
Data communications equipment	265	279	294
Facsimile terminals	145	175	213
Fiber-optic systems	41	52	65
Intercom systems	85	69	59
Navigation aids (except radar)	343	370	400
Paging systems, public & private	75	79	84
Radar (air, land, & marine)	1,879	2,048	2,171
Radio, total	732	811	885
Broadcast equipment	203	221	232
Land-mobile (mobile & base stations)	317	355	398
Microwave systems	137	152	165
Satellite earth stations	75	83	90
Telecommunications equipment, total	2,844	2,893	2,942
Customer-premise equipment	599	601	603
Telephone & data-switching systems, private	503	522	541
Telephone & data-switching systems, public	1,129	1,163	1,197
Transmission & carrier equipment	613	607	601
Television equipment, total	102	108	113
Broadcast	60	64	67
CATV (except cables)	N. A.	N. A.	N. A.
CCTV (including educational, industrial, & medical)	42	44	46
Data processing & office equipment, total	**11,111**	**12,715**	**13,821**
Computer systems, total	6,930	8,077	8,777
Personal computers (under $5,000)	1,045	1,568	1,920
Microcomputers ($5,000 to $20,000)	723	839	897
Minicomputers ($20,000 to $100,000)	1,041	1,197	1,269
Superminicomputers ($100,000 to $400,000)	733	814	846
Mainframe computers ($400,000 to $5 million)	3,323	3,588	3,768
Supercomputers and minisupercomputers	65	71	77
Data-input peripherals	122	133	145
Data-output peripherals	761	845	938
Data-storage subsystems	1,359	1,563	1,720
Data terminals	1,091	1,222	1,356
Electronic office equipment, total	848	875	885
Copiers	499	525	540
Electronic typewriters	212	210	206
Word-processing systems	137	140	139
Software, total	**4,369**	**5,56**	**6,084**
Industrial equipment, total	**1,372**	**1,560**	**1,774**
Inspection systems (ir & X-ray)	36	41	48
Machine-tool controls (including numerical-control systems)	61	70	80
Motor controls (speed, torque)	126	144	162
Process-control equipment (including loggers, consoles, etc.)	917	1,054	1,213
Programmable controllers	232	251	271
Semiconductor production equipment, total	**66**	**68**	**70**
Power supplies, noncaptive, total	**91**	**96**	**105**
Bench & lab	6	7	7
Industrial	30	28	31
OEM & modular, total	55	61	67
Linear	20	20	21
Switching	35	41	46
Test & measurement equipment, total	**350**	**371**	**397**
Amplifiers, lab	1	1	1
Analog voltmeters, ammeters, and multimeters	4	4	4
Automatic test equipment, total	55	62	75
Discrete-component testers	5	6	7
IC testers	22	26	32
Pc-board testers	28	30	36
Calibrators & standards, active and passive	5	5	6
Counters, time & frequency	10	10	9
Digital multimeters (including probes & accessories)	20	22	23
Logic analyzers	18	20	22
Microprocessor development systems	27	25	23
Microwave test & measurement instruments	63	68	73
Oscillators	2	2	3
Oscilloscopes	29	28	27
Recorders & plotters (including chart & X-Y types)	62	68	71
Signal generators (pulse, sweep, & function), total	33	33	34
Analog	11	10	9
Synthesized	22	23	25
Spectrum analyzers	21	23	26
CAD/CAE equipment, total	**416**	**454**	**494**
EQUIPMENT, TOTAL	**28,223**	**31,416**	**34,209**

All figures in current U.S. dollars.

Exchange rate: 5.55 francs to $1

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MICROELECTRONICS

healthy 9% to $2 billion to pace the market. This year, radar makers will see their market slow to a more modest 6% as the government throttles back on defense spending, and radio equipment should slow to 9% growth. One bright spot is cellular radio, which should surge 12%; the sector is getting a boost from an upcoming pan-European network that AEG, Alcatel, and Nokia expect to have operating by 1991.

Yet another surging sector is facsimile terminals. Sales zoomed ahead 21% last year to $175 million and should match that pace in 1989, the *Electronics* survey predicts. Revenues should total $213 million. Private-branch-exchange gear is starting to fly high as well, industry watchers say. All the same, there's a problem. Fax machines and small PBXs are on their way to becoming consumer items, for which the market will operate under the "laws of the jungle," says Jean-Paul Brianchon of the Bureau d'Informations et Previsions Economiques (BIPE), an economic forecasting and consulting group based in Neuilly, just outside Paris.

As for the once-soaring market for Minitel video-text terminals, it will flatten out this year. In 1988, a million Minitels were installed, mostly for free by France Telecom. This year the figure will likely drop—the extent is not known since France Telecom has yet to disclose its 1989 plans.

FRANCE COMPONENTS

	(millions of dollars)		
	1987	**1988**	**1989**
Semiconductors, total	**899**	**1,112**	**1,206**
Discrete, total	223	242	250
Diodes, total	86	96	98
Microwave (above 1 GHz)	9	10	10
Rectifiers	50	56	57
Signal (less than 100 mA)	9	10	10
Varactor	5	6	6
Zener	13	14	15
Thyristors	18	20	22
Transistors, total	119	126	130
Bipolar, total	76	79	79
Power (1 W or more)	40	42	43
Small-signal	36	37	36
Field-effect, total	29	31	33
Power (1 W or more)	13	14	16
Small-signal	16	17	17
Rf & microwave	14	16	18
Integrated circuits, total	676	870	956
Custom & semicustom	32	43	52
Linear ICs, total	170	204	225
Communications (codecs, etc.)	32	38	42
Consumer-product ICs	70	85	93
Interface (buffers, decoders, drivers, etc.)	19	22	24
Op amps (monolithic only)	27	32	36
Voltage references and regulators	14	17	19
Timers	8	10	11
Memories, total	153	216	252
Application-specific (including video)	0	0	9
Random-access memory	90	137	157
Read-only memory	63	79	86
Microprocessors and microcomputers	139	195	213
Standard logic families, total	182	212	214
Bipolar	110	126	126
CMOS	72	86	88
Hybrid & modular components, total	**271**	**275**	**283**
Optoelectronic devices, total	**66**	**75**	**81**
Discrete light-emitting diodes	18	20	21
Laser diodes	5	5	6
Optically coupled isolators	12	14	15
Photoconductive cells (light-dependent resistors)	3	4	4
Photodiodes & phototransistors	3	4	4
Photovoltaic cells	6	7	8
Readouts (LCD, LED, fluorescent, etc.)	19	21	23
Tubes, total	**571**	**585**	**604**
Cathode-ray (except TV)	43	45	47
Image-sensing	36	36	35
Light-sensing	9	9	10
Power tubes (magnetrons, klystrons, etc.)	144	145	145
TV picture, total	339	350	367
Color	334	345	363
Monochrome	5	5	4
Passive & mechanical, total	**1,749**	**1,867**	**1,939**
Capacitors, total	277	298	303
Fixed	270	290	295
Variable	7	8	8
Connectors, plugs, & sockets	358	385	401
Filters, networks, & delay lines	28	29	30
Loudspeakers (OEM)	54	55	55
Printed circuits & interconnection systems	456	491	518
Quartz crystals (including mounts & ovens)	63	66	67
Relays (for communications and electronic equipment)	28	29	30
Resistors, total	138	143	149
Fixed	86	90	93
Networks	14	14	15
Potentiometers & trimmers	38	39	41
Switches & keyboards	152	159	166
Transformers, chokes, & coils	195	212	220
COMPONENTS, TOTAL	**3,556**	**3,914**	**4,113**

All figures in current U.S. dollars.

Exchange rate: 5.55 francs to $1

What's more, the traditionally strong market for public switching has gone stagnant, rising a bare 3% this year and last; 1989 sales will total $1.2 billion. Sales of carrier equipment will again edge down 1% to $601 million. There's little surprise in either case: the all-digital switching network has been cut over, and the upgrading necessary for an integrated services digital network is not far enough along to have an impact on the market.

A similar stagnation affects the markets associated with TV broadcast, studio production, and distribution networks (except cable). The "wait and see" attitude applies not only to new installations, which are at a standstill, but also to replacement equipment. There are only a few applications pending to increase TV broadcast coverage for the two newest French networks, which may result in the installation of a handful of transmitters.

As for consumer electronics, there are few mysteries this year. New products like compact-disk players, camcorders, and microwave ovens will show respectable growth rates in the 7% to 12% range. Former market mainstays like color-TV and stereo sets will languish. And the lift from the new arrivals won't be enough this year to hold the 4% growth pace of 1988. The *Electronics* survey pegs the 1989 market at $4.2 billion, up only 3% over 1988.

Color TV, which accounts for roughly a third of all consumer-electronics sales, will hover around the $1.3 billion mark for the second year in a row; chalk that up to heavy price pressures as much as stagnant set sales. A lot of buyers are staying out of the market, waiting to see what will happen with high-definition TV and satellite direct broadcast.

Suppliers of test and measurement equipment seem to be set for the second reasonably good year in a row. The survey spots this market at $397 million, a 7% rise over the $371 million registered last year.

But the figures probably underestimate the true market, says Jean-Marie Laffargue, di-

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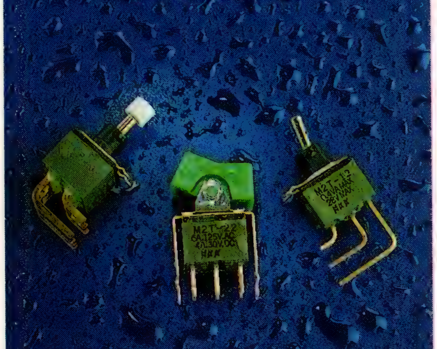

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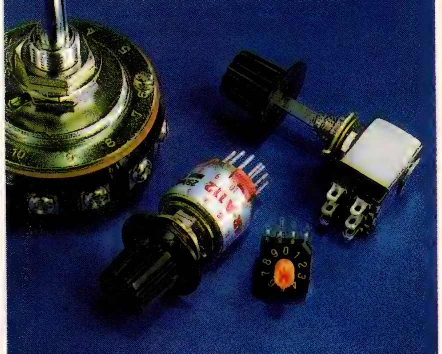

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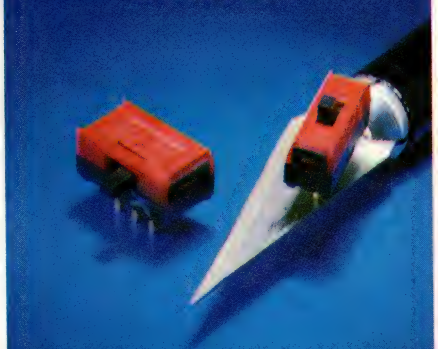

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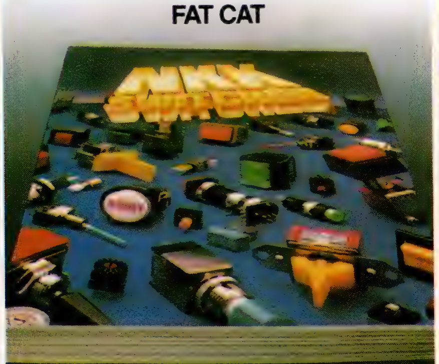

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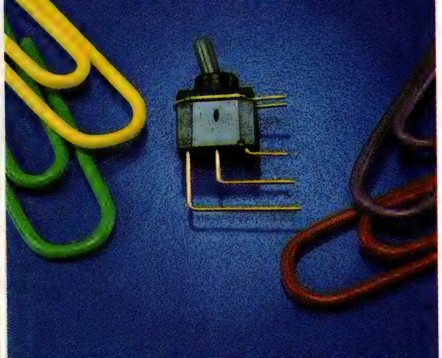

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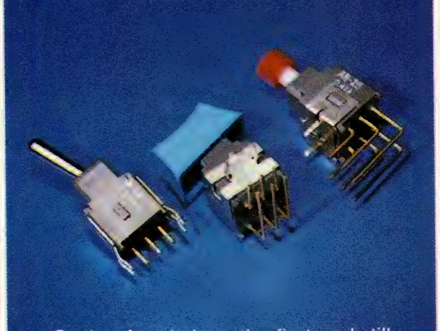

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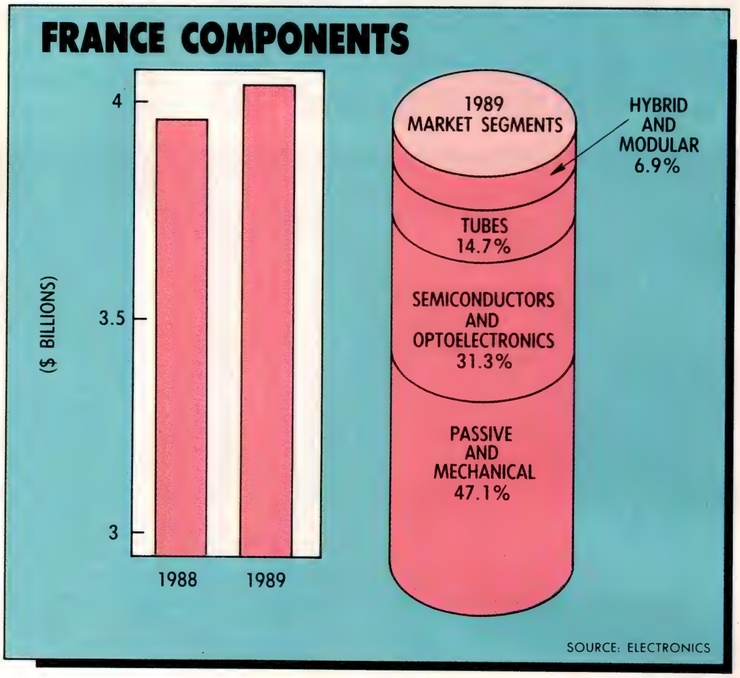
rector of the industry trade organization Symecora. The French T&M industry is experiencing a revolution in the products and services it supplies to customers. "The hardware is increasingly nonspecific, and only the software needs to be tailored to each application," he says. This means, for example, that many functions are performed by a stock personal computer, most often not supplied by the T&M manufacturer. "The market is thus becoming increasingly service-oriented, to the detriment of hardware," he maintains.

Even so, French T&M makers need more than 7% hardware growth to thrive. So they are turning to export markets. In 1987, the last year for which full figures are available, exports increased 10% to $749 million; preliminary figures for 1988 are almost as encouraging. "French T&M equipment is competitive and exports are doing well, even into traditionally difficult markets such as Germany," says Laffargue.

The trade winds in the $4.1 billion French components markets won't blow as briskly this year as they did last, when the market moved out of the doldrums with a 10% surge to $3.9 billion. The 1989 gain should be 5%, the *Electronics* survey predicts. "The upswing experienced in 1988 should continue in 1989," says Thomson's Caillot. But in his view, the outlook is fragile: the growth rate, he says, stems in large part from recovery from an industry stall two years ago.

Even a cursory look at the charts will spot the culprits: sales of semiconductors will climb to $1.2 billion, a rise of some 9%. That's far short of the heady 24% growth recorded last year, when sales reached $1.1 billion. Passives are forecast for a modest 4% rise to $1.9 billion, an easing of last year's 7% growth rate; and tubes will mark a modest 3% rise to $604 million.

The sharp turnabout in the growth rate for chips has a lot of semiconductor people on edge. ICs account for some 80% of the market, and a heavy proportion of these parts go into PCs.



SOURCE: ELECTRONICS

HALF OF ALL MEMORY CHIPS GO INTO PERSONAL COMPUTERS

"Roughly 16% of the semiconductor market is going into PCs," says Jean-Philippe Dauvin, corporate economist at SGS-Thomson Microelectronics, the Franco-Italian semiconductor conglomerate. "And this market represents half the market for memories [overall] and two-thirds the market for dynamic random-access memories. A slowdown there would result in a brutal crash in the memory market, sufficient to wipe out all growth in semiconductors." This crash, he estimates, could be right around the corner.

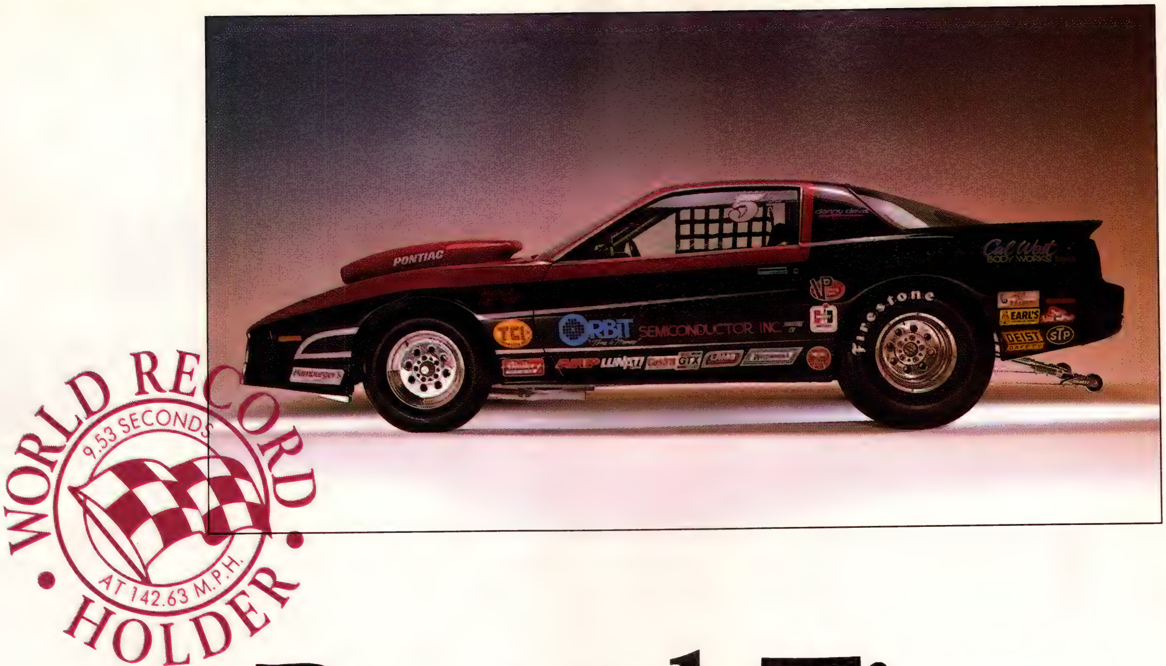
"In any case, the semiconductor market was at its peak in 1988 and will certainly slow down in the next year or two," says Marianne Andrault, the components expert at the BIPE. "The question is: when and how much?"

In IC categories, linear devices will climb 10% to $225 million, halving their 1988 growth rate, and memories will rise 17% to $252 million, against a 41% rise last year. RAM sales will increase 15% to $157 million after climbing a steep 52% last year, according to the *Electronics* survey. The slowdown is also seen in microprocessors and microcomputers, rising 9% to $213 million against a 40% climb in 1988.

For optoelectronic devices, too, a slowdown is in store. Where this still small sector rose 14% to $75 million in 1988, it will climb just 8% to $81 million in 1988.

For many industry observers and independent analysts, the notion of a domestic components market, in Europe anyway, has little meaning, and should be enlarged to embrace all of Europe at the least. "Even French companies are buying components outside of France, assembling overseas, and selling in a third country," says Dauvin.

Meanwhile, the heavyweight tubes sector should grow to $604 million, a gain of just 3% over 1988, when the market was up a mediocre 2.5%. Power tubes for professional and military applications will continue to slide slightly, but the mainstay category, color tubes, will pull up the totals. They could get an additional lift if French set makers move rapidly into high-definition TV, notes Andrault. ☐



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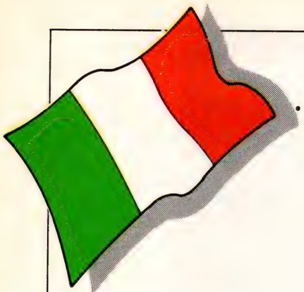


ITALY

SETTLING DOWN AFTER A SOARING '88

Like a Ferrari closing fast on a flock of small Fiats, the Italian electronics industry will downshift a gear or two in 1989. The *Electronics* forecast predicts the country's equipment markets will be worth $18.5 billion this year. That's a respectable 9% rise over last year's $17.1 billion, but a bit of a fall from 1988's 11% gain. In components markets, the drop-off is sharper: from last year's robust 18% rise to $2.2 billion, these markets will grow just 6% to $2.3 billion.

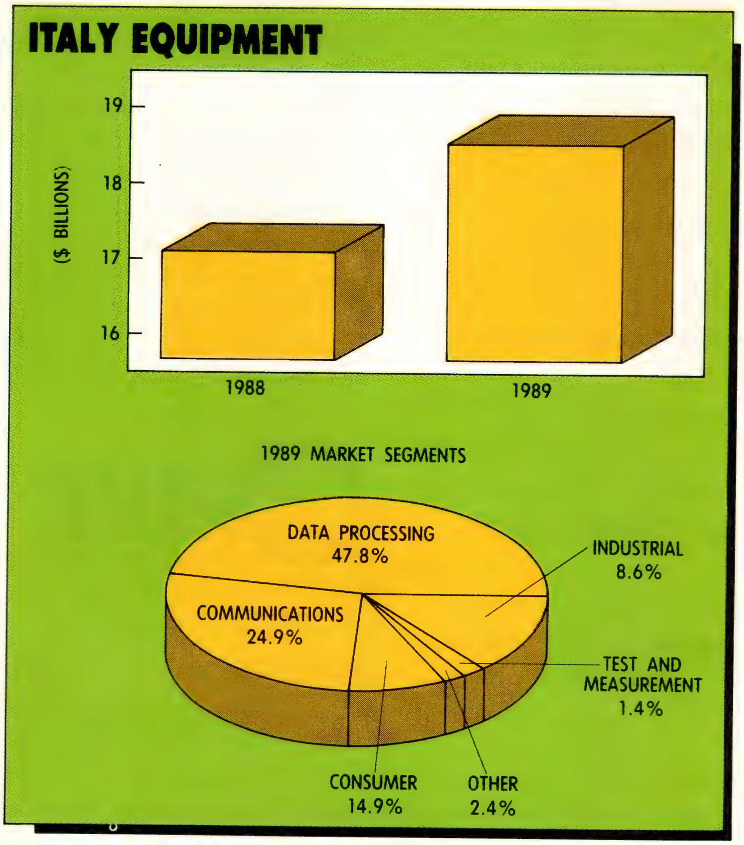
The forecast is surprising only to the extent that many observers would have predicted a much sharper decline in growth. A slowdown of some kind seemed inevitable after 1988, which was the best year the Italian economy in general and its electronics industry in particular have seen in a long time. Gross national product was up more than 3%, and domestic electronics production was up more than 7%, according to Roberto Taranto, managing director of Teknibank SpA, a market research company based in Milan.

The strong business climate kept the computer sector humming, and affluent consumers bought digital TVs, compact-disk players, camcorders, and videocassette recorders as never before. Telecommunications equipment makers got a lift, too, as the government moved to bring the country's telephone system up to par with the rest of Europe by 1992.

From spectacular in 1988, then, the country's economy and its electronics markets will slip to merely good in 1989. Taranto expects the Italian GNP to grow about 2.5% this year, with its electronics segment running at about 6%. All of the major market segments are expected to continue growing, albeit at lower rates than last year's.

Data-processing gear, for example, should rise some 7% to $6.3 billion; last year's growth was 8%. The communications sector seems set for a 7% gain—nine percentage points off from last year—that will carry it to $4.6 billion. Consumer markets will remain surprisingly strong, matching last year's 9% pace for $2.8 billion in sales. Components will suffer from a downturn in semiconductor consumption: coming off a 1988 hike of 40%, semiconductors will grow just 8% to $891 million, with the main subcategory—integrated circuits—rising by 8% also to $704 million. That's well below last year's 50% growth rate.

In the kingpin data-processing sector, the survey puts this year's computer systems market at $4.2 billion, a 9% gain. The big question for 1989 is what's going to happen to medium-sized machines, says Alessandro De Maria, a manager in the Studies and Strategies Division at Ing. C. Olivetti & Co. in Ivrea. The *Electronics* survey shows a 10% increase for microcomputers, minis, and superminis. The largest


ITALY EQUIPMENT

computer sector—mainframes—will be slowing slightly, from 7% growth last year to 6% this year, with sales of $1.2 billion. Personal computers will become a $1.09 billion market in 1989, a 9% rise.

De Maria foresees a lower growth rate today than he expected a year ago as far as traditional office applications are concerned. In some sectors of office equipment, De Maria points out, the shrinking sales simply reflect computers taking over. The expected 4% drop in data terminals, from $274 million to $262 million, for example, is a result of the increasing use of PCs as terminals as well as stand-alone units.

OFFICE EQUIPMENT SLOWS DOWN AS COMPUTERS TAKE OVER

In the consumer arena, newer products like camcorders and compact-disk players are growing very rapidly, as one might expect them to. A less obvious, but nonetheless exciting, area is color TV, points out Mauro Taraborrelli, division manager for Deutsche ITT Industries GmbH in Assago. Although set sales will rise only 5% to reach $1.1 billion, Taraborrelli expects the number of fully digital sets sold this year will bound upward 50% to reach 300,000 units.

Probably no market segment better fits the description of 1989 as good but not spectacular than telecommunications. In 1987, the Italian government set up a long-term program to upgrade the nation's telephone system. Its goal is to increase the number of households that have telephones from the present level of about 75% to 100% by 1997 or 1998. Last year was the first year of that program.

Its effect is clearly reflected in the 1988 figures for overall telecommunications systems, which show a spurt of some 17%, to $3.1 billion from about $2.6 billion. Spending on the modernization program is scheduled to continue at a steady rate, however, with increases only for price hikes. The plan is to install 2 million

ITALY EQUIPMENT

	(millions of dollars) 1987	1988	1989
Consumer electronics, total	**2,308**	**2,525**	**2,760**
Audio equipment, total	678	746	809
Car	136	140	144
Compact-disk players	42	54	68
Phonographs & radio-phonographs	28	28	29
Radios (table, clock, & portable)	52	53	53
Radio/recorder combinations	104	110	115
Stereo equipment	202	241	274
Tape recorders & players	114	120	126
Home video equipment, total	422	518	637
Camcorders	72	115	173
Cassette players & recorders	350	403	464
Television receivers, total	1,049	1,095	1,144
Color	1,006	1,057	1,110
Monochrome	43	38	34
Other consumer products, total	159	166	170
Calculators (personal and professional)	66	64	62
Musical instruments	42	44	45
Microwave ovens	51	58	63
Communications equipment, total	**3,730**	**4,319**	**4,610**
Data communications equipment	114	128	140
Facsimile terminals	188	235	258
Fiber-optic systems	N. A.	N. A.	N. A.
Intercom systems	34	32	29
Navigation aids (except radar)	157	172	189
Paging systems, public & private	24	32	44
Radar (air, land, & marine)	260	281	301
Radio, total	269	307	352
Broadcast equipment	20	23	27
Land-mobile (mobile & base stations)	127	143	181
Microwave systems	122	141	144
Satellite earth stations	N. A.	N. A.	N. A.
Telecommunications equipment, total	2,627	3,074	3,237
Customer-premise equipment	535	696	774
Telephone & data-switching systems, private	256	296	300
Telephone & data-switching systems, public	1,400	1,568	1,624
Transmission & carrier equipment	436	514	539
Television equipment, total	57	58	60
Broadcast	27	28	29
CATV (except cables)	N. A.	N. A.	N. A.
CCTV (including educational, industrial, & medical)	30	30	31
Data processing & office equipment, total	**5,481**	**5,911**	**6,306**
Computer systems, total	3,481	3,844	4,175
Personal computers (under $5,000)	896	1,003	1,093
Microcomputers ($5,000 to $20,000)	321	360	396
Minicomputers ($20,000 to $100,000)	704	795	878
Superminicomputers ($100,000 to $400,000)	361	406	446
Mainframe computers ($400,000 to $5 million)	1,070	1,145	1,213
Supercomputers and minisupercomputers	129	135	149
Data-input peripherals	80	87	94
Data-output peripherals	403	451	501
Data-storage subsystems	518	570	614
Data terminals	254	274	262
Electronic office equipment, total	745	685	660
Copiers	549	503	493
Electronic typewriters	180	168	155
Word-processing systems	16	14	12
Software, total	**2,015**	**2,234**	**2,562**
Industrial equipment, total	**1,313**	**1,445**	**1,573**
Inspection systems (ir & X-ray)	18	20	22
Machine-tool controls (including numerical-control systems)	111	123	134
Motor controls (speed, torque)	126	139	152
Process-control equipment (including loggers, consoles, etc.)	964	1,061	1,156
Programmable controllers	94	102	109
Semiconductor production equipment, total	**19**	**20**	**22**
Power supplies, noncaptive, total	**78**	**86**	**91**
Bench & lab	5	6	6
Industrial	22	25	27
OEM & modular, total	51	55	58
Linear	21	22	22
Switching	30	33	36
Test & measurement equipment, total	**234**	**250**	**264**
Amplifiers, lab	2	2	2
Analog voltmeters, ammeters, and multimeters	6	6	6
Automatic test equipment, total	50	55	59
Discrete-component testers	3	4	4
IC testers	18	19	21
Pc-board testers	29	32	34
Calibrators & standards, active and passive	3	3	3
Counters, time & frequency	5	6	6
Digital multimeters (including probes & accessories)	12	13	14
Logic analyzers	8	9	10
Microprocessor development systems	18	20	22
Microwave test & measurement instruments	44	45	46
Oscillators	3	3	3
Oscilloscopes	26	27	27
Recorders & plotters (including chart & X-Y types)	24	26	28
Signal generators (pulse, sweep, & function), total	14	14	16
Analog	8	8	8
Synthesized	6	6	8
Spectrum analyzers	19	21	22
CAD/CAE equipment, total	**250**	**312**	**360**
EQUIPMENT, TOTAL	**15,428**	**17,102**	**18,548**

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ICs: Taking the High Side- Logic IC manufacturers are slugging it out for the high profits in high-speed digital circuits. This battle is driving technology through new speed barriers. Managers will read about the latest moves of bipolar silicon manufacturers to counter the threats from the feisty GaAs startups and coming developments in mixing bipolar with low-power CMOS.

Computers: Giving it a Spin- Electronic OEMs are taking their mass storage bottlenecks to the bank —a bank of disk drives, that is! The large arrays of small drives could solve input/output problems and replace more expensive subsystems based on big-platter technology. Readers find out how farcan this concept go.

Data Communications: The Serial Link- Despite the attention given to the Open Systems Interconnect standards effort, the mainframe network world still evolves around IBM's Systems Network Architecture. Chip makers are suddenly launching new products that cut the cost of serial SNA links and add protocol flexibility.

Optoelectronics: Seeing the Light- New trends in fiber optics and integrated opto ICs will spur the technology towards promising new markets. This package will explore the new technology and business opportunities.

BUSINESS / MANAGEMENT ISSUE

Out in Orbit: Now that the U.S. shuttles are up and running again, the race to commercialize space is heating up. What will be the impact on electronic companies geared for space ? Industry managers will learn of the new growth and new technologies that could launch new markets in the 1990s.

DEPARTMENT FEATURES

Executive Briefing: Ringing up Sales- Cellular telephone systems networks are up and running and now the battle is on for big business. Readers will get an eyeful of new telephony technology appearing on the horizon that could change the evolving markets.

Letter From: Arizona- This southwestern state continues to bask in strong growth of electronics business, but industry leaders there are concerned that Arizona's government may not be doing enough to promote itself. Many believe Arizona blew a major opportunity when it did not make a major push to land the semiconductor consortium Sematech. Our regional correspondent will give our readers the latest word on the prospects of continuing good times in the state.

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new lines a year, half of them replacements for existing lines, says Luigi Sarati, who heads the research and strategy department at Italtel SpA, Milan, the leading Italian telecommunications-equipment producer. Interestingly, telephone-agency officials have decided to use nothing but fiber optics for long-distance communications in the future, according to Roberto Preti of the Strategies and Development Department at STET, the government's telecommunications-industry holding company in Rome. Existing coaxial cables that have been installed but not yet put into service will be abandoned, he says.

Ordinarily, a forecast 6% gain in the Italian components market would inspire mild elation among the country's parts suppliers. And that's what's in store according to the projection, a rise this year to $2.3 billion from the 1988 level of $2.2 billion. But like their equipment-making brethren, the parts people are coming off a sensational year that makes this year's outlook pale in comparison.

The effect will be most dramatic in the semiconductor sector. Personal computer makers bought dynamic random-access memories and microprocessors at an unprecedented rate in 1988, driving the semiconductor market up 40% to hit the $826 million mark. The gain in sight for the year ahead is just under 8%, to $891 million.

It could be better and it could be worse. As Pierantonio Palerma, publisher for the Electronic Cluster within the Jackson Publishing Group in Milan, points out, everything depends on Olivetti, Italy's largest consumer of semiconductors by far, and its only really important native computer maker.

At the end of 1988, Olivetti was dramatically slowing acceptance of semiconductors it had already ordered. Depending upon many factors, most importantly its relationship with AT&T Co. (for which it manufactures personal computers), Olivetti may slash its semiconductor procurements in 1989. Expecting them to do exactly that, many observers therefore project a growth in the semiconductor market of no more than 5%.

Luckily, chip makers have other customers. The upward bounce in digital-TV set production, for example, will help out the semiconductor industry. ITT's Taraborrelli explains that each of these sets contains about $30 worth of digital ICs, in addition to $5 or $6 worth of other semiconductor components. So the rapid proliferation of digital TV is of major importance to ITT, SGS-Thomson Microelectronics, and other semiconductor makers.

Then there is automotive electronics and Marelli Autronica SpA, the electronics arm of the giant Fiat automobile company. Marelli is eagerly pursuing electronic applications for automobiles, and is in fact planning a new engine-control system for use in a high-volume automobile. The system should be in full production in 1989.

Such developments will boost the automotive electronics market by some 50% this year to reach about $96 million, according to Jackson's Palerma. In the charts, this growth is reflected in custom and semicustom integrated circuits, projected to shoot up 26% to reach $72 million. ☐

ITALY COMPONENTS

	(millions of dollars) 1987	1988	1989
Semiconductors, total	**588**	**826**	**891**
Discrete, total	154	175	187
Diodes, total	62	68	71
Microwave (above 1 GHz)	6	7	7
Rectifiers	39	41	43
Signal (less than 100 mA)	8	9	9
Varactor	2	2	2
Zener	7	9	10
Thyristors	21	24	24
Transistors, total	71	83	92
Bipolar, total	56	65	70
Power (1 W or more)	36	41	45
Small-signal	20	24	25
Field-effect, total	7	8	12
Power (1 W or more)	4	4	7
Small-signal	3	4	5
Rf & microwave	8	10	10
Integrated circuits, total	434	651	704
Custom & semicustom	43	57	72
Linear ICs, total	133	145	151
Communications (codecs, etc.)	28	31	33
Consumer-product ICs	34	37	38
Interface (buffers, decoders, drivers, etc.)	34	37	38
Op amps (monolithic only)	19	22	23
Voltage references and regulators	12	12	13
Timers	6	6	6
Memories, total	96	221	233
Application-specific (including video)	3	3	3
Random-access memory	59	177	186
Read-only memory	34	41	44
Microprocessors and microcomputers	71	125	136
Standard logic families, total	91	103	112
Bipolar	45	50	52
CMOS	46	53	60
Hybrid & modular components, total	**108**	**118**	**127**
Optoelectronic devices, total	**31**	**33**	**36**
Discrete light-emitting diodes	6	7	7
Laser diodes	1	1	1
Optically coupled isolators	6	6	6
Photoconductive cells (light-dependent resistors)	1	1	1
Photodiodes & phototransistors	3	3	4
Photovoltaic cells	4	4	5
Readouts (LCD, LED, fluorescent, etc.)	10	11	12
Tubes, total	**397**	**422**	**446**
Cathode-ray (except TV)	14	17	19
Image-sensing	11	14	16
Light-sensing	4	4	4
Power tubes (magnetrons, klystrons, etc.)	62	64	66
TV picture, total	306	323	341
Color	291	310	331
Monochrome	15	13	10
Passive & mechanical, total	**737**	**795**	**834**
Capacitors, total	149	158	164
Fixed	143	152	158
Variable	6	6	6
Connectors, plugs, & sockets	152	174	187
Filters, networks, & delay lines	10	11	12
Loudspeakers (OEM)	42	44	42
Printed circuits & interconnection systems	150	166	180
Quartz crystals (including mounts & ovens)	14	14	15
Relays (for communications and electronic equipment)	54	58	60
Resistors, total	46	47	50
Fixed	24	25	25
Networks	4	4	5
Potentiometers & trimmers	18	18	20
Switches & keyboards	59	61	62
Transformers, chokes, & coils	61	62	62
COMPONENTS, TOTAL	**1,861**	**2,194**	**2,334**

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A SINGLE STANDARD EMERGES FROM THE UNIX TUG-OF-WAR

As AT&T and OSF adopt X/Open's standard, their competition moves to a new level

by Tom Manuel

EXECUTIVE BRIEFING is a monthly feature of Electronics *that provides managers with a concise review of developments in fields that are making frequent headlines.*

The last 12 months have seen the Unix operating system engulfed in a whirl of controversy and newsmaking developments. The good news at the beginning of 1989 is that the world of many Unixes is finally converging into one standard. The bad news is that it is very unlikely there will be a single implementation of that standard. Two opposing groups of companies are firmly asserting their rights to implement their own brands of Unix.

What this means is that the competition between the Open Software Foundation and the group of companies committed to AT&T Co.'s version of Unix will move to a different level. It will no longer be a matter of competing standards; instead, a user can choose one implementation or the other for business reasons, based on either business relationships his company has, price, or technical reasons not related to the standard itself—such as system performance, reliability, or special features. But whichever implementation is chosen, all application software should remain compatible at the source-code level.

The Unix community's hopes for unity rest mainly on the progress being made toward agreement on a standard specification brought together and codified by X/Open Co. Ltd. of London and San Francisco. The member companies of X/Open are working on a proposal that will be presented to the two implementation groups—OSF and Unix International Inc. Formerly known as the Archer Group, Unix International is the organization founded late last year by 29 companies who are committed to Unix System V and the new implementation (Version 4.0) being developed by AT&T and Sun Microsystems. The X/Open proposal would create a formal and close relationship among the three organizations, which makes X/Open—a neutral body—guardian of the Unix standard. OSF and AT&T would be implementers of that standard with Unix International to guide future development of the System V implementation.

The proposal's prospects look good, and unabated growth in the Unix sector of the computer marketplace is expected. That sector is, and should continue to be, one of the fastest growth markets in the entire electronics industry.

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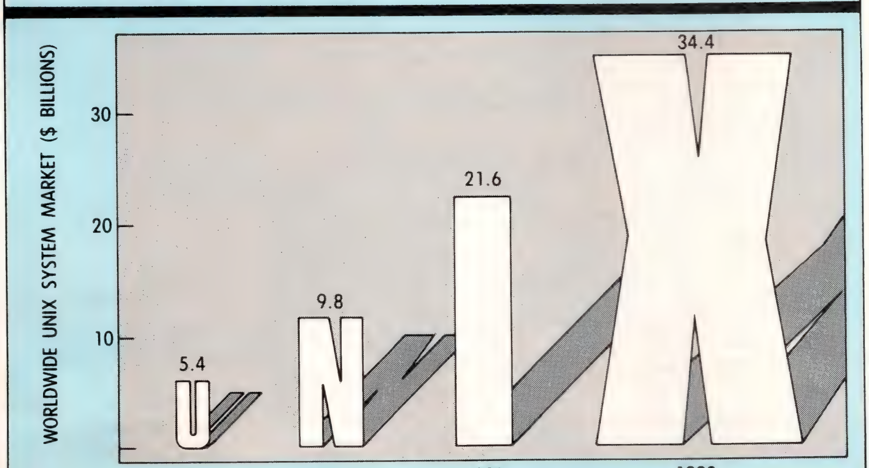


SOURCE: INFOCORP

If X/Open succeeds, it is in no small part due to efforts that have been going on for some time. One important new standard is Posix (Portable Operating System Interface for Computer Environments), which was accepted as a standard last year by the Institute of Electrical and Electronics Engineers. X/Open and other organizations are working to add important pieces not codified in Posix. For example, standards for computer security in Unix environments are well on their way. Other pieces falling into place are user-interface standards and extensions for supercomputer environments.

The war of the Unixes is all but over if X/Open succeeds in becoming the recognized single source for the Unix standard. Many observers think this is likely. "I believe that eventually there will be one compliance standard—Posix [the IEEE Unix standards committee], the U. S. government, and X/Open will get together," says Russ Aldridge, director of marketing for the Unix Systems division of Convergent Technologies Inc., San Jose, Calif., now a part of Unisys Inc. of Detroit, Mich., and Blue Bell, Pa.

ONE FOR ALL. "I think the schism that has been created [in Unix] is an unfortunate apparent conflict," says Edward W. Scott Jr., vice president of marketing at Pyramid Technology, Mountain View, Calif. "I know of no one in the Unix world that doesn't want a single standard, except the two major computer vendors—IBM wants AIX adopted and DEC wants Posix to help it keep its VMS [operating system] proprietary," he adds. "The view of the rest of the industry, including both OSF and Unix International members, is that a single standard is best for everyone. We hope that the two groups can get together," says Scott.

The value of open systems is in the portability of programs. Applications written to conform to the standard will run on any vendor's computer that also conforms, with no more effort than recompiling the source code. Unix has become the foundation for open systems in the computer industry; it runs on more hardware over a broader range of price and performance than any other operating system.

But Unix, which was developed at AT&T's Bell Laboratories in 1969, has evolved into many variations. Not surprisingly, there has been controversy and jockeying among organizations and companies over which Unix should become the industry standard.

It appears that the only remaining big disagreement today is not over the standard but over who will control the implementation of that standard. AT&T and Sun Microsystems Inc., with the support of Unix International, are forging ahead with their implementation of AT&T System V.4. The competing Open Software Foundation is proceeding with its implementation based on AIX version 3 from IBM, which evolved from AT&T System V, Release 2, and includes the features of V.3. Future versions of both brands of Unix, V.4 and OSF-1, will combine the features of System V and the Berkeley versions of Unix and both will conform to emerging industry standards like Posix.

Unix System V.4 from AT&T, due for release late this year, already has a large following. "With System V.4 combining System V, Berkeley, and Xenix versions of Unix, a very large customer base will be taken care of," says Barry James Folsom, vice president and general manager of the East Coast division of Sun Microsystems in Billerica, Mass.

OSF-1, too, has many committed backers. But V.4 and OSF-1 are implementations, and it looks as if both will conform to a single standard, which will be under the stewardship of X/Open.

IT WON'T MATTER. It will be the marketplace that decides which of the two Unix implementations gets the most business. But will it matter for the user? "Honestly speaking, I don't think it will matter very much," says William Bonin, vice president of North American operations for X/Open. "The market for each [implementation] will be determined by business issues, since both are technically good and both have large groups of good development people," he says.

The market for Unix systems has been growing rapidly. Unix has taken over most of the scientific and technical computing field—essentially all technical work stations and most supercomputers run Unix—and it is beginning to make large inroads into commercial computing. Now that an industry standard is finally emerging, the market will take off on an even steeper growth path.

Infocorp, the Mountain View, Calif., market research company, forecasts a total worldwide Unix systems market of $21.6 billion by 1990, growing to $34.4 billion in 1993. The company estimates that the 1988 market will be $9.8 billion. When DEC, Hewlett-Packard, IBM, and other industry heavyweights announced last May that they were pouring over $100 million into the new OSF organization because they were unsatisfied with AT&T's approach to keeping the standard open, it underlined very clearly that Unix has become a major focus for every computer vendor worldwide, whether or not they continue to develop their own proprietary operating systems.

Government agencies are starting to adopt X/Open's Unix definition

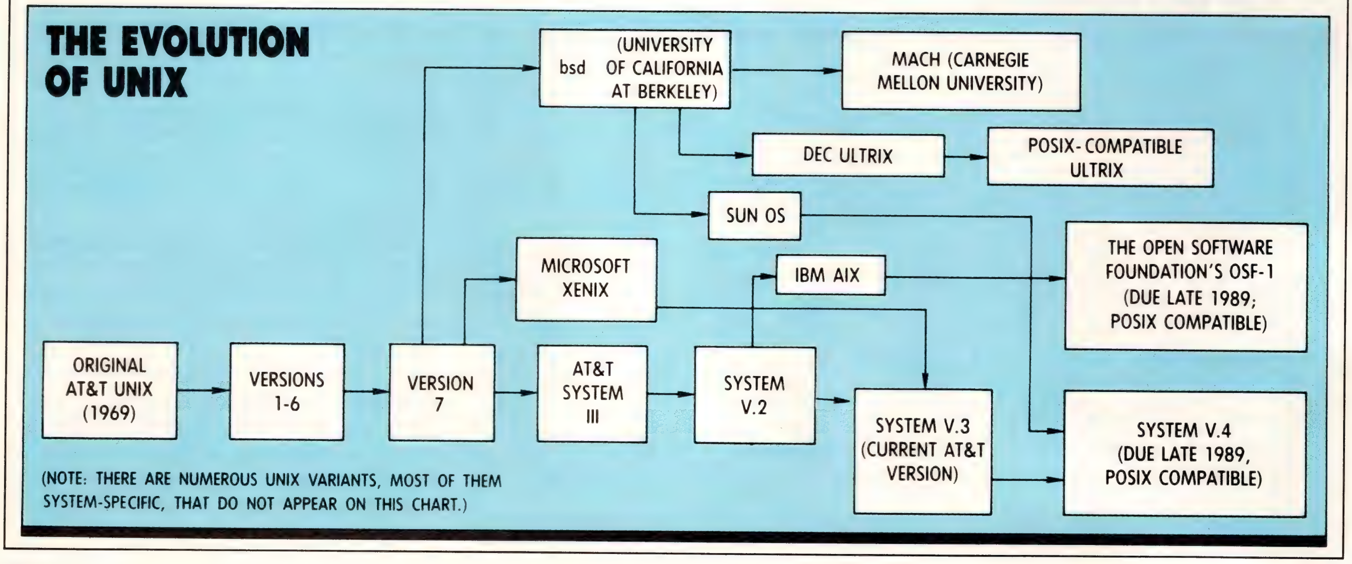
Thanks for this are owed to many groups that have been working on Unix standards. The efforts of the IEEE's P1003 Posix committee, which grew out of work done by /usr/group, an industry association based in Santa Clara, Calif., have been recognized by X/Open and OSF, as well as AT&T and Unix International; they have all recommended adoption of the Posix standard. The first Posix standard, the P1003.1 operating system interfaces and C language binding standard, which specifies an application-program environment, was approved by the IEEE standards board last August.

But Posix is not a complete operating-system standard. Each organization adopting Posix intends to go beyond the scope of P1003.1 in specifying additional standard features. X/Open's Portability Guide for its Common Applications Environment specifies a complete standard applications interface environment that includes programming languages, data management, windowing, and networking interfaces. In early 1989, X/Open will meld P1003.1 with phase two of the X/Open Portability Guide's third edition.

With OSF and the AT&T-Sun alliance both adopting the X/Open CAE, the X/Open standard will soon have the critical mass needed to create a universe of truly open systems that users and software vendors can rely upon. Users currently using AT&T Unix System V.3 and writing programs that conform to AT&T's current System V Interface Definition, as well as those who are using the Berkeley bsd version of Unix or Microsoft's Xenix, will be able to adopt the new standard with relative ease. In addition, those who wait for OSF-1 will also be compatible with the standard.

Donal O'Shea, vice president of operations and communications at OSF, makes it very clear that "we are not in dispute with anyone over standards. Both implementations [V.4 and OSF-1] will conform to the Posix standard and the X/Open Common Application Environment," he says. "What OSF is after is to answer the need for an industrial-quality version of Unix that companies can safely base their business upon—OSF's mission is to produce products that do that," he adds.

The most important result coming out of all the controversy is that whichever implementation dominates the industry—or if neither does—the end users will be winners. OSF-1 and V.4 will be source-code compatible. Users who develop their own programs will be able to create one version that will run on systems from multiple vendors. If they buy a system


THE EVOLUTION OF UNIX

ORIGINAL AT&T UNIX (1969)
VERSIONS 1-6
VERSION 7
bsd (UNIVERSITY OF CALIFORNIA AT BERKELEY)
MACH (CARNEGIE MELLON UNIVERSITY)
DEC ULTRIX
POSIX-COMPATIBLE ULTRIX
SUN OS
MICROSOFT XENIX
IBM AIX
AT&T SYSTEM III
SYSTEM V.2
SYSTEM V.3 (CURRENT AT&T VERSION)
THE OPEN SOFTWARE FOUNDATION'S OSF-1 (DUE LATE 1989; POSIX COMPATIBLE)
SYSTEM V.4 (DUE LATE 1989, POSIX COMPATIBLE)

(NOTE: THERE ARE NUMEROUS UNIX VARIANTS, MOST OF THEM SYSTEM-SPECIFIC, THAT DO NOT APPEAR ON THIS CHART.)

that runs the other implementation, all they have to do is recompile.

Independent software vendors also win. They will only need to develop and maintain one version of an application program; but they will have to compile, label, and distribute two versions, one for each brand of Unix. System vendors, however, will have to decide on one implementation or the other. For most vendors, it will be too costly to support both.

With the standard settling down, the floodgates are open and the rush of open systems products is starting. The X/Open CAE is already something that can be used now. Some Posix- and CAE-compliant products have been announced and many more are on the way.

The X/Open branding program [*Electronics*, October 1988, p. 175] was initiated last September. When computer systems and software carry the X/Open brand, users can buy with confidence that the software will run. X/Open-branded products have been announced by several computer and software vendors. X/Open has just published a directory that contains more than 225 applications.

The confidence provided by the X/Open CAE and branding program make them an excellent solution for government procurement administrators to rely upon. They must satisfy dual requirements for standard products to lower the cost of software and shorten the development times and they must follow competitive bidding procedures.

Government agencies worldwide are starting to specify CAE compliance in their procurements. Late last year four European agencies adopted the X/Open CAE as a guideline for computer equipment purchases. They include the Commission of the European Communities and government agencies in the UK, West Germany, and Sweden. X/Open is working with a number of U. S. government agencies to help them write CAE-compliant specifications. The North Atlantic Treaty Organization and the Supreme Headquarters Allied Powers Europe are studying the CAE, according to X/Open's Bonin.

SECURITY CONCERN. One block to the acceptance of Unix in commercial computing and government—especially military—systems is the issue of system security. There is an enormous user interest in obtaining higher levels of security under Unix (a number of levels of security have been defined by the National Security Agency).

Unix is notorious for being weak in the area of system security, but upon close scrutiny, many security features can be found in Unix. The features, however, have been buried by poor documentation. To remedy this, the Security Working Group at X/Open has developed a security guide. The guide documents ways to implement a "decent commercial-user [level of] security," according to X/Open's Bonin. The features documented, which include file permissions, passwords, and groupings of users, do not require modification of Unix. "We have written a manual for system managers to pull together all the features for security in Unix," says Bonin.

But there are needs for greater security than the commercial-level security provided by the optional features already in Unix. The IEEE P1003.6 subcommittee on security is working on specifying a set of standard security extensions for Unix. The strict security requirements of the U. S. Department of Defense as specified in its security document, called the Orange Book, will have to be addressed by Unix systems of the future through extensions to the system.

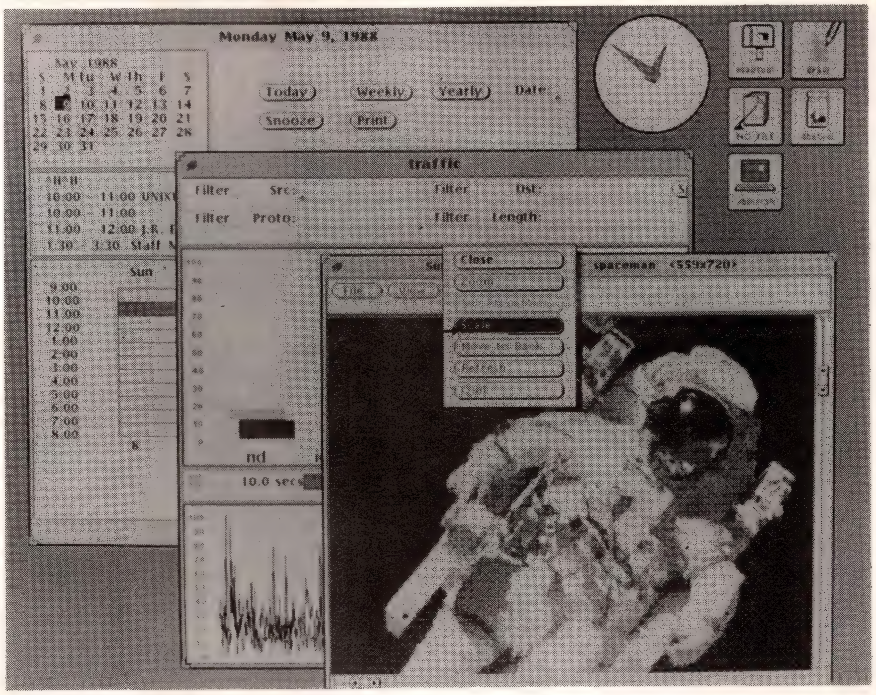
X/Open also has a working group looking into Unix extensions for government and military security levels to identify how these Orange Book requirements can be satisfied in a standard way.

Another important issue bearing on applications portability is that of standard user interfaces. To minimize porting difficulties, the industry needs a small number of standard user interfaces—one, ideally, but it appears likely that at least two will exist in the marketplace, if not many. The Unix segment of the computer industry has jumped on a base user-interface technology for networked systems and made it a de facto standard: the X Window System developed at the Massachusetts Institute of Technology.

X Window is not a complete user interface in itself; it leaves implementation details to users. Both OSF and AT&T are adopting the X Window System as the basis for user interfaces. AT&T and Sun have developed the Open Look user interface on top of X Window as the standard user interface to go with System V.4. Many other X Window user interfaces have been developed, like DecWindows from Digital Equipment Corp. and Hewlett-Packard Co.'s NewWave.

OSF has not announced its selection of a standard user interface, but it is close to doing so. OSF requested the submission of user-interface technologies for its review and selection. Out of the 40 submitted, OSF qualified 26 candidates; Open Look, DecWindows, and NewWave are among them. The OSF staff completed its review and evaluation and will publish a complete statement of the rationale for the selection on or about Jan. 13.

Several other standards efforts are under way within the Unix community, mainly aimed at broadening the applicability of Unix, making it competent for applications it was not originally intended for. Extensions for using Unix in real-time systems is one example; another is adding capabilities to make Unix-based systems perform better in transaction-processing applications. Support for multiprocessing environments will become more important as parallel computers become more popular. Supercomputer users are also working on extensions, even though some of them are already using Unix. Oddly enough, they want a facility for batch processing of programs, a procedure most of the computer world has abandoned. Supercomputer users also want Unix support for very high-speed input and output of data. ☐

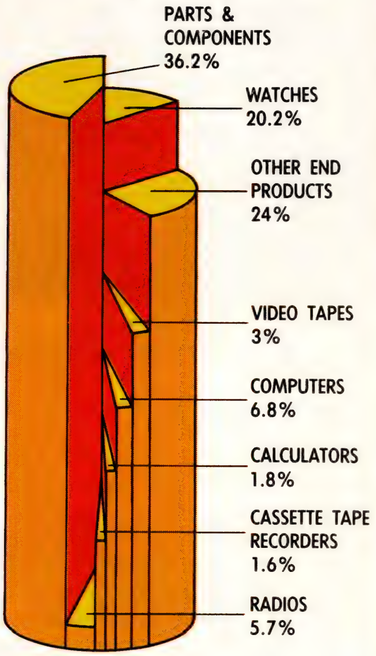


A windowing user interface called Open Look, based on MIT's X Window System and developed by AT&T and Sun Microsystems, will be used in AT&T's Unix implementation.

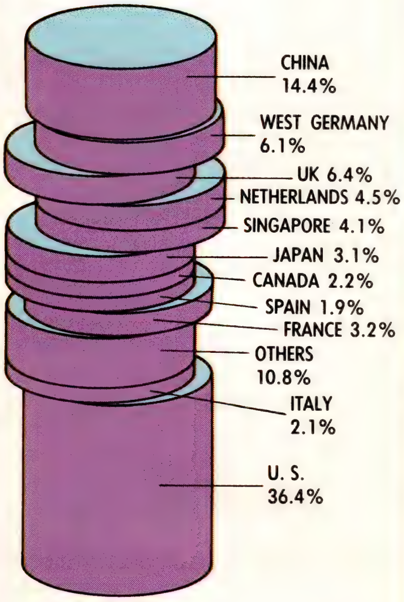
INDICATORS

STACKING UP HONG KONG'S ELECTRONICS EXPORTS

*FIRST NINE MONTHS IN 1988



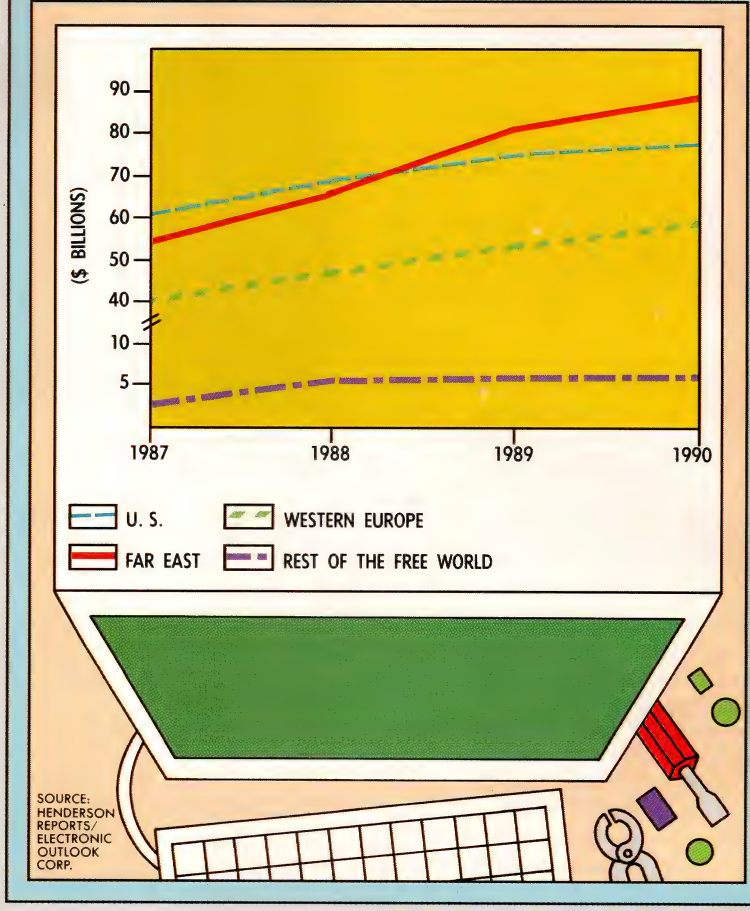
BY PRODUCTS



BY MAJOR MARKETS

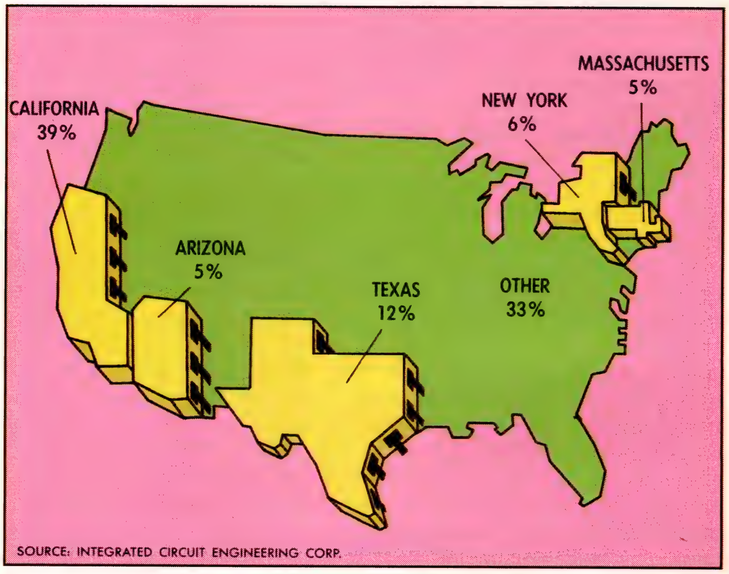
SOURCE: HONG KONG TRADE DEVELOPMENT COUNCIL

WHERE COMPUTER AND OFFICE GEAR WILL BE BUILT



SOURCE: HENDERSON REPORTS/ ELECTRONIC OUTLOOK CORP.

WHERE THE CHIP PLANTS ARE



SOURCE: INTEGRATED CIRCUIT ENGINEERING CORP.

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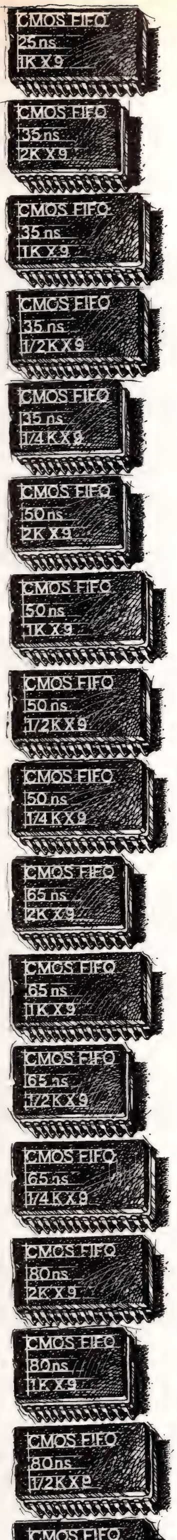

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Circle 146

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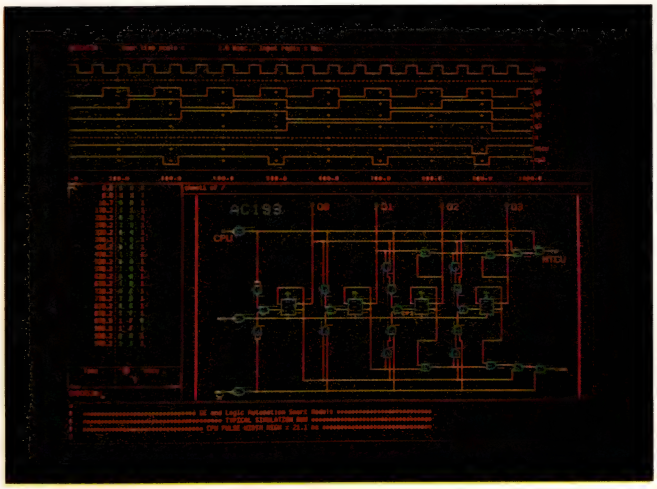

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IT'S A NEW BALL GAME IN CANADA-U. S. TRADE

Opportunity, yes, but new competition as well

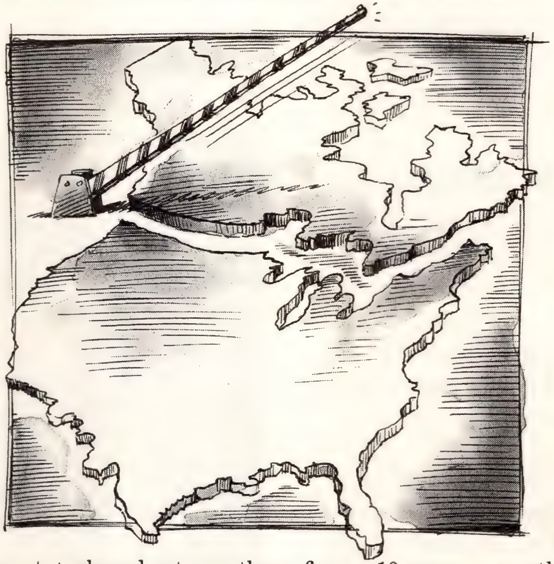
America's biggest trading partner isn't Japan. Nor is it France, Hong Kong, Korea, Taiwan, the UK, or West Germany. Canada is the world's largest consumer of U. S.-made goods, and it's a major producer of electronics, automobiles, and timber bound for U. S. customers. In electronics alone, the two nations traded more than $6 billion of merchandise across the 49th parallel between January and July 1988, a pace that should easily break the 1987 record of $8.4 billion for a full year.

Now Canadian-U. S. trade is poised to take off even further. When Canada's voters backed Prime Minister Brian Mulroney in last November's election, they in effect said yes to a U. S.-Canada Free Trade Agreement that will eliminate, over 10 years, all protective tariffs between the two countries. The result spells opportunity for electronics companies on both sides of the border, and their executives are now busy trying to figure out how to make the most of it.

The fact is, the agreement changes the rules of the trading game, and that means companies will have to step back and take a good, long look at their strategies. "You may have new opportunities now," says Peter Bowie, a partner and director of the High Technology Group at Touche, Ross & Co. in Ottawa. "But you may have new competitors too."

Canada's high tariffs, designed to protect its young and fragile industries, have historically hindered U. S. penetration into many Canadian markets, particularly those for communications equipment, such as private branch exchanges and telephones. But Canadian businesses have paid a price, living in constant fear that U. S. protectionist measures aimed at deflecting Asian or European producers might also effectively lock Canada out of its biggest export market.

But all that is past. As of Jan. 1, 1989, the first of many tariffs will fall. Those on electronic goods ranging from telephones to diodes and from semiconductors to PBXs will be eliminated. Cross-border trips to service Canadian-built electronic systems functioning in the U. S. will no longer be hindered by Customs agents unwilling to let technology out of the country. Tariffs on other products will be phased out over three, five, or 10 years. What does that mean to electronics executives, analysts, and industry associations alike?



"We expect a shared benefit to industries on both sides of the border," says Ted Heydinger, vice president at the Computer and Business Equipment Manufacturers Association in Washington. "You'll see an increase in trade and an increase in joint activity between U. S. and Canadian companies."

The whole idea behind the treaty, Heydinger explains, "is that not only will it be easier for those who are trading already, but it will increase trading across our borders by small and mid-sized companies that might not have tried it before."

The agreement will also make it easier for American companies to deal with their Canadian subsidiaries, Heydinger says. "There will be less paperwork, fewer fees, and fewer restrictions." That means businesses will be able to achieve improved economies of scale, allowing them to dedicate, say, a Canadian plant to the production of modems and a U. S. plant to the manufacture of telephones, rather than to diversify each plant to make both products.

by Tobias Naegele

Tariffs play a major role in a company's decision to export a product, and changes in tariffs can mean a change in strategy. AT&T, freed of the 17.5% tariff on telephones and PBXs imported from the U. S. to Canada, expects to make its prices far more competitive, says David Zorb, director of government relations for AT&T Canada Inc. in Montreal. The company could even make a play for the Canadian consumer market.

But tariffs aren't the whole story, says Bowie of Touche, Ross. "Fundamentally, the FTA was not an issue of tariffs," he says. "It was an issue of access." Canada was the only major industrial nation without guaranteed access to a market with more than 100 million people, he says.

In nuts-and-bolts terms, for one Canadian company the treaty "means I don't have to do the board-stuffing work I was doing in the U. S. anymore," says James Bailey, president and chief executive officer of Gandalf Technologies Inc. in Ottawa. He says costs are nominally the same in the U. S. and Canada, but since the Canadian dollar is worth about 20% less, "you should be producing more cheaply in Canada."

He also says the threat of improved access to Canadian markets by U. S. competitors is not a significant worry. Gandalf derives only 28% of its revenue from Canadian sales, he says, with the rest spread out around the world. "So even if I lose 5% or so of our domestic-market share," he says, it beats the risk of having the U. S. and other markets closed to Canadian goods. "Frankly, Canadians are damned lucky to have the U. S. and its 240 million consumers so close," he says.

Other business decisions will also need to be made, such as whether or not to establish subsidiaries. Canadians may now be less inclined to establish U. S.-based service centers. Before the agreement, service professionals were often turned back at the border by Customs officials who refused to allow the technicians to travel out of Canada. "There had been problems going south," Bowie says. "But under the Free Trade Agreement, there's guaranteed access."

C&C Computers and Communications

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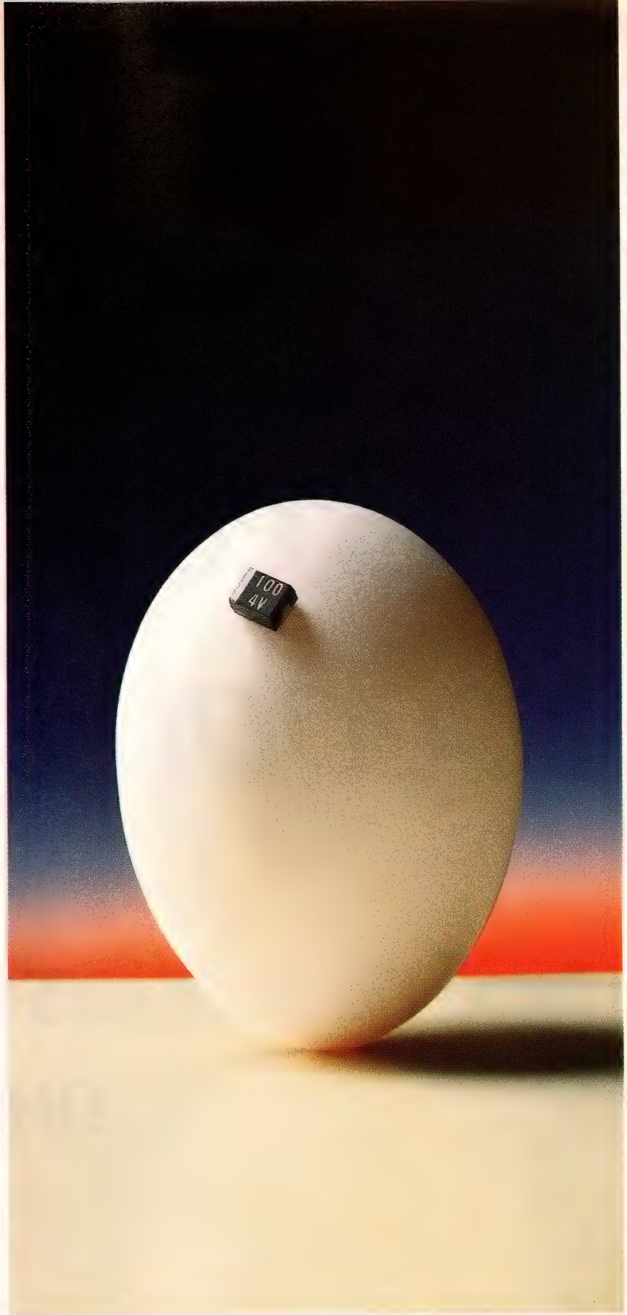

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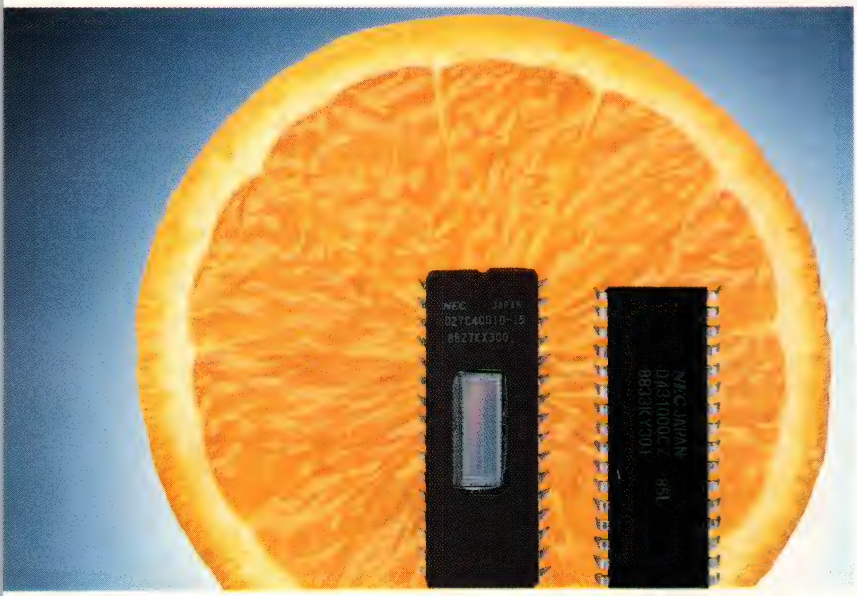

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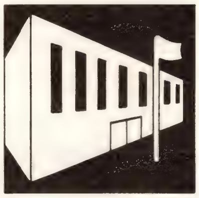
MATSUSHITA DEAL OPENS NEW MARKETS, BUILDS CREDIBILITY FOR SEQUENT

New firm, Pana-Sequent, will sell business-transaction systems in Japan

BEAVERTON, ORE.



At first glance, an alliance between Sequent Computer Corp. and Matsushita Electric Industrial Co. Ltd. looks like a mismatch. Sequent, based in Beaverton, Ore., is barely six years old. Although it's growing fast, revenue for 1988—its best year so far—will reach $75 million at most. Matsushita, headquartered in Osaka, Japan, is a huge, multinational company with revenue that is almost a thousand times greater than Sequent's—about $60 billion a year.

But this David and Goliath have indeed struck a deal. They are forming a joint-venture company, Pana-Sequent, that will sell Sequent's parallel-processing systems in Japan. For Sequent, the deal means credibility and new markets.

To be based in Osaka, the firm will initially employ 17 people, to be drawn from the ranks of both Sequent and Matsushita, and be run by two senior managing directors: Gary Rieschel, Sequent's manager of Asia-Pacific marketing, and Hideyo Sugimoto, the manager of Matsushita's Information Equipment Section. A board of directors, also drawn from both firms, will oversee the operation. (The name is Matsushita's first step toward renaming itself Panasonic, after its best-known product line; eventually, all Matsushita ventures will have names carrying the "Pana" prefix.)

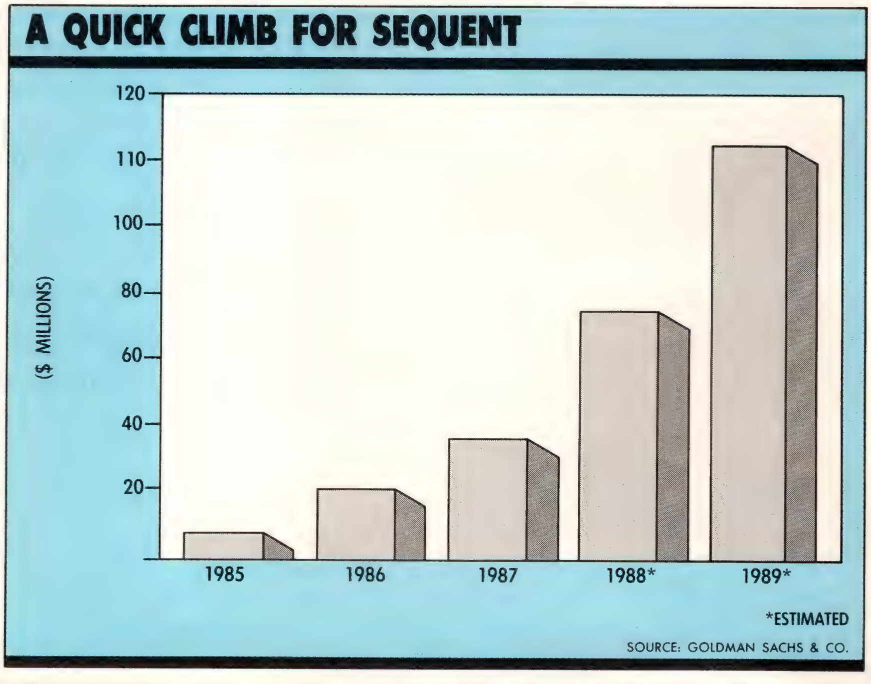
Sequent's management acknowledges that until fairly recently the idea of a deal probably wouldn't have occurred to a company like Matsushita. "We didn't have the credibility to do such a thing two years ago," says Michael Simon, vice president of marketing, who will sit on Pana-Sequent's board. But the successes of the last two years have won that credibility for Sequent, he says.

Sequent itself has sold more than 60 systems in the Far East—30 of them in Japan—and more than 400 worldwide. Its reputation has been bolstered further by a number of deals with original-equipment manufacturers, the most important of which is with Siemens AG in West Germany; Siemens has installed some 2,000 Sequent-based systems in Europe. Those sales translate to a rise in revenue from $4.3 million in 1985 (the first full year Sequent had a system on the market) to $38.5 million in 1987. Analysts predict 1988 revenue will be between $70 million and $75 million and 1989 revenue well over $100 million. Profits of $4 million in 1987 should climb to $6 million in 1988 and jump to $13 million in 1989.

All of which is pretty impressive for a company that was founded just six years ago and introduced its first product as recently as December 1984. That product, though, and the two that followed it—the Balance B8, the B21, and then the new Symmetry Series [*Electronics*, May 28, 1987, p. 76]—were breakthrough systems. With them, Sequent became the first computer maker to successfully apply microprocessors, configured in parallel and operating transparently to users, to large-scale business-transaction processing. And in doing so, the company has cut the price/performance level for transaction processing drastically—so drastically that Sequent's systems threaten to push out of the market the minicomputers and mainframes that have long handled transaction processing.

In the latest Sequent product line, for example—the Symmetry series, based on Intel's 80386 processor—performance ranges from 8 million to 120 million instructions/s at prices from $89,000 to more than $1 million. That translates to a price/performance advantage over minis and mainframes of more than 50%. The Sequent S81 can use up to 30 processors to support as many as 1,000 users at an average system cost of $8,000 per transaction per second. The typical cost of the same transaction per second using a minicomputer would be $40,000; using a mainframe, it would be $65,000.

FIVE TARGETS. The foundation of Sequent's success is its concept of how to implement parallel processing. The company's founders decided that their systems would meet five criteria. They would use standard, off-the-shelf microprocessors; be based on a transparent multiprocessing architecture; adhere to industry standards; provide relational data-base-management systems; and run fourth-generation language-development software. Also, the Sequent design yields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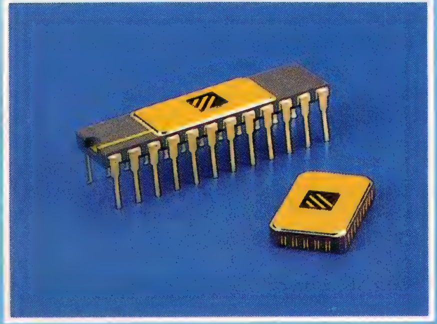

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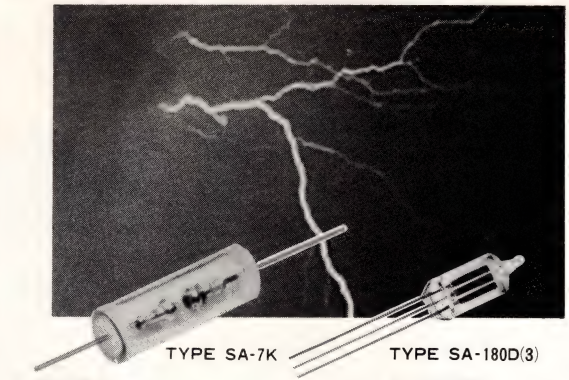

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Type	Breakdown Voltage (V) DC	Insulation Resistance (Ω)	Maximum Surge Current (8×20us) KA	Life Times at 500A
SA-80SS	80±10%	10^{10} min	1.0	1000
SA-200SS	200±10%	10^{19} min	1.0	1000
SA-80	80±10%	10^{10} min	1.5	1000
SA-140	140±10%	10^{10} min	1.5	1000
SA-200	200±10%	10^{10} min	1.5	1000
SA-250	250±10%	10^{10} min	1.5	1000
SA-300	300±10%	10^{10} min	1.5	1000
SA-7K	7000±1000V	10^{10} min	—	5000
SA-10K	10000±1000V	10^{10} min	—	5000
SA-180D(3)	180±10%	10^{10} min	2.5	1000

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computer systems that are incrementally extendable in performance. The customer buys only as much as he needs and adds more as he needs it; the more a user buys, the lower the price per unit.

The founders called the concept embodying those criteria transparent multiprocessing. The key word is "transparent." The new systems had to look as if they were doing things the way a user was accustomed to seeing them done, but do them faster and cheaper. "The approach we took was Machiavellian," says Casey Powell, now chairman and chief executive officer. "If you want to change something, make it look like what it is now, don't make it look like a change."

The founders had great faith in their concept when they started the company in January of 1983—enough so that they didn't bother writing a business plan. "Business plans are vehicles to raise money," Powell says. "We didn't need that." The founders came from management positions in companies like Apple, Intel, and Tandem. Their experience, along with their ideas, attracted all the venture capital they needed.

But they did need an operating plan, Powell says—"a plan to run a company." They used it for the first three years, then modified it as conditions demanded. "What makes Sequent what it is today is the fact that we are not afraid to call a spade a spade and change when neccessary," Powell says. Probably the biggest change was a decision to refocus the marketing strategy. Sequent originally sold its computers primarily to scientific and research organizations. Early in 1987, the company broadened its aim to include business computing as well.

In business automation—where the computer performs, controls, and records the actual business transaction of a company, rather than doing back-room chores like accounting— systems must perform extremely reliably and maintain perfect data integrity. In addition, buyers usually insist on doing business with a stable, reputable, and successful vendor—they most often choose IBM Corp., Digital Equipment Corp., or one of the leading vendors of fault-tolerant systems, notably Tandem Computers Inc.

Sequent is starting to break into this select circle. Its systems have racked up impressive records for reliable operation, achieving 99.9% uptime, measured in the field, and a measured mean time betweeen failure of more than 11,000 hours. "The machine runs without failure for 1.5 years, 24 hours per day, 7 days a week," Powell says.

The deal and all it promises have Sequent champing at the bit. "We have worked six years for the right to be in the race," according to Powell. "Let Sequent onto the track and we can beat them on anything." *–Tom Manuel*

ADDS IS BRINGING A LOT OF IT BACK HOME

HAUPPAUGE, N. Y.

Advanced Digital Data Systems Inc. is out to prove that onshore production is an idea whose time has come. Beginning this month, the Long Island-based terminal company will move half of its production from the Pacific Rim back to the U. S. But ADDS isn't waving the flag as it swallows the bitter pill of anemic profits. Rather, says the company, a weaker dollar and stricter tariff enforcement have put America back in the manufacturing business.

"In the electronics industry generally, the economics are starting to shift toward the U. S.," says president David Laws. "It is still slightly cheaper to build terminals in the Far East, but as the dollar continues to weaken, I think in the near future it will become less expensive to build them here."

In mid-November, ADDS, a subsidiary of NCR Corp. of Dayton, Ohio, signed with contract manufacturer Omnishore Inc. of Carson City, Nev., to produce a new line of terminals it plans to market worldwide. As production of the new

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models ramps up in Carson City, contract manufacturers making the older models in Taiwan will be phased out.

The numbers tell the story: when ADDS moved production offshore in 1984, a terminal cost $320 to manufacture on Long Island and $270 in the Far East. Now, the comparison is the same $320 in the U. S. versus $300 in the Far East. The 20-year-old company is the first independent terminal maker to move production back, and it was the last to take it abroad.

Contrary to popular conviction, labor does not account for enough of the cost of a terminal to make the decision go one way or the other (see graph, opposite). In 1984, ADDS was manufacturing terminals in a highly automated U. S. facility requiring 1 man-hour of work per system at $5.75 an hour. The Taiwanese pay was just $1 per hour, but both were peanuts compared with materials costs. Cost of components was 25% less in the Far East in 1984; now it's just 6% less.

The problem contract manufacturers in Hong Kong, Korea, and Taiwan face is currency exchange. They must buy components from the Japanese and pay in a yen that has been rapidly appreciating while selling to ADDS in depreciating U. S. dollars. To compound these woes, as of Jan. 1, the Reagan administration is levying a 3.9% tariff on terminals imported from Hong Kong, Korea, and Taiwan. They had previously been exempted because those countries had "disadvantaged nation" status, says Laws.

It didn't take a genius, says Laws, to figure out that the cost-of-manufacturing pendulum was swinging away from the Far East. Feeling the currency pinch, ADDS' contractors there were persistently asking for relief from their contracts—which ADDS gave temporarily. "Common sense tells you that if people are losing money, they aren't going to produce for you very long," says Laws. "They didn't want to lose the business, but it was really a matter of how they were going to lose it: by us taking some of our products away or by the products not being cost-effective." Far Eastern manufacturers losing out on the commodity terminal business are turning to more value-added products such as computer-aided-design terminals, he says.

BACK IN THE U. S. Omnishore started building products in July 1987. In its 60,000-ft^2 facility, it integrates design, parts procurement, manufacturing, testing, and delivery into its production strategy. Other Omnishore customers include IBM Corp. of Armonk, N. Y., and Unisys Corp. of Blue Bell, Pa. Pilot products for ADDS will be built in the first quarter of 1989, and quantity production will start in the second.

About to celebrate its 20th birthday, ADDS can boast other industry firsts. Its Viewpoint terminal, introduced in 1980, was the first to break the $1,000 barrier, and ADDS was the first to introduce a 70-Hz refresh rate in its products. About 25% of its products go to parent company NCR, and the rest bear the ADDS brand name. The company projects it will sell about 120,000 units in 1988, but does not divulge its revenue or profits.

Besides the strictly cost-related benefits of manufacturing in the U. S., says Laws, the strategy also delivers more flexibility. Product mix can be changed quickly; ADDS has five models, each offering the choice of three phosphors (green, amber, or paper white), and two voltage configurations. The demand for the paper-white screen is particularly volatile, says Laws, but Far East suppliers cannot react quickly because of their labor-intensive production techniques. That can mean unsold inventories.

Other hidden costs of offshore manufacturing are dead inventory and administrative costs. "Basically, you pay for

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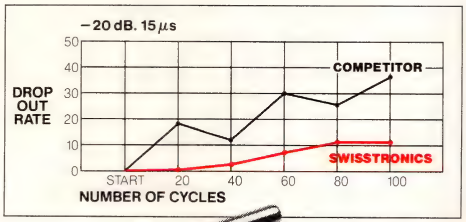

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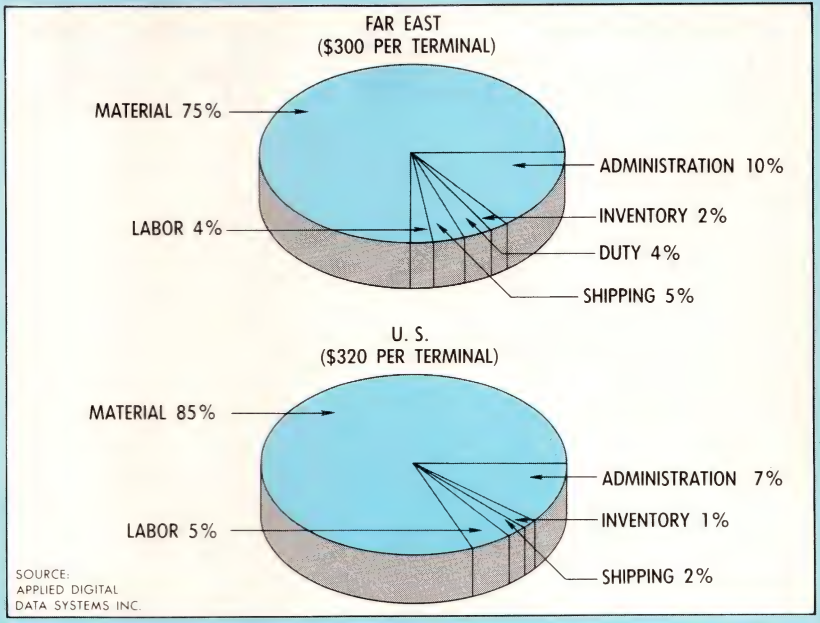
the product when it arrives on the manufacturer's dock, but you can't sell it until it arrives in the U. S. or Europe," says Laws. Administrative costs of doing business offshore include facsimile, telex, time delays, and housing staff members abroad to monitor quality control.

Laws says ADDS will retain a 50:50 mix of onshore and offshore production. The economics are not that favorable in the U. S., he says, and "most of the development work in video technology is being done in the Far East. We'll maintain a presence there just to tap into the technology advances."

While Laws admits he could be riding the back of a tiger in bringing production back home, he is confident the strategy will work for the foreseeable future. "As long as we're running a trade deficit, we'll continue to see pressure on the dollar. In 10 to 15 years, the pendulum might swing back, but that is an immense deficit to eliminate," he says. The best way to strengthen the dollar, he adds, is exactly what is happening in Carson City: every terminal manufactured there is one less that will be imported. *–Jack Shandle*

OFFSHORE MANUFACTURING COST CATCHES UP



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THE SECRET'S OUT: ZILOG'S IN THE BLACK

CAMPBELL, CALIF.

Dogged determination and a redefined product charter have put Zilog Inc. into the black for its owner, Exxon Corp.

In addition to the venerable Z80 and follow-on general-purpose microprocessor products, Zilog has gained success in the microcontroller market with its single-chip Z8 and Super8 family of 8-bit controllers. Buoyed by their use in embedded-control applications, 8-bit central-processing units are expected to be a $259 million market in 1989, up from $214 million in 1988. Sales of 16-bit parts should grow to $375 million from $311 million, while 32-bit CPUs should rise to $211 million from $175 million.

The struggle for profitability has taken close to a decade. Since an initial success with the 8-bit Z80, the Campbell-based company has taken a backseat to others—most notably Intel of Santa Clara, Calif., and Motorola Inc. of Schaumburg, Ill.—in the 16- and now the 32-bit general-purpose computing markets.

Credit for Zilog's focusing away from pure commodity components and toward targeted solutions goes to Edgar Saks, the company's president and chief operating officer since 1985, industry watchers say. By the end of its fiscal year in 1989, Saks's leadership will have doubled the components' revenue to the current level of about $100 million. Since the company is a wholly owned unit, exact sales and profitability are not released, but under Saks it has managed to chalk up profits for fiscal 1987 and 1988, with last year's profits doubling the previous year's.

Its diversification strategy doesn't mean Zilog won't be a mainstream supplier. Its problems in the mainstream started with design delays during the development of its 16-bit Z8000 processor family. A new but incompatible instruction set prevented the processor from capturing many of the popular system designs and from building on the large software base of its Z80 8-bit predecessor. That now venerable 8-bit chip, which dominated the early business-computer market thanks to the CP/M operating system (the precursor to Microsoft's MS/PC-DOS), is still alive and well, according to Saks.

STUMBLE. The Z80's extensions into the 16-bit world, although announced several years ago, also suffered from development delays due to personnel cuts caused by losses in the mid-1980s.

Thanks to a limited number of licenses and a concept dubbed "superintegration" (akin to the large macrocells used in semicustom-circuit design), sales of Z80-based chips are still increasing. And, Saks says, "that concept has been extended to encompass many of the 8-bit peripheral circuits that Zilog popularized in the heyday of the 8-bit and early years of the 16-bit computers." Circuits such as serial data-communication controllers, parallel interfaces, and counter-timers are now "large building blocks in the company's chip-design tool set, with which application-focused chips can be developed in a much more timely manner."

Founded in the early 1970s, Zilog got its first cash investment from New York-based Exxon in 1975, and in 1981 it became a wholly owned unit. However, until 1987 it floundered financially, draining money from Exxon to keep the doors open. Making the tough decisions about market direction and putting tight controls on expenses, production, and customer orders was Saks's strategy for the turnaround.

Saks attributes the profitability to a better management structure using what he calls "forward controllership" to obtain very up-to-date decision-making information regarding sales, manufacturing, operations, finance, and engineering. The result: better-informed employees and sounder business decisions.

What does the future hold? Saks is looking for further proliferation of its Z80, Z8, and Z8000 families, with new core cells added to its design-automation system. He hopes to make significant inroads into data communications. The popular serial-communications controller and direct-memory-access controller cells are being combined in some "superintegration" chips that by 1990 will include intelligence in the form of a Z8000 CPU core. A technology deal with Catalyst Semiconductor will yield ultraviolet erasable programmable read-only memory technology that will be put to work on the chips that are coming into production in late 1989 and 1990. *–Dave Bursky*

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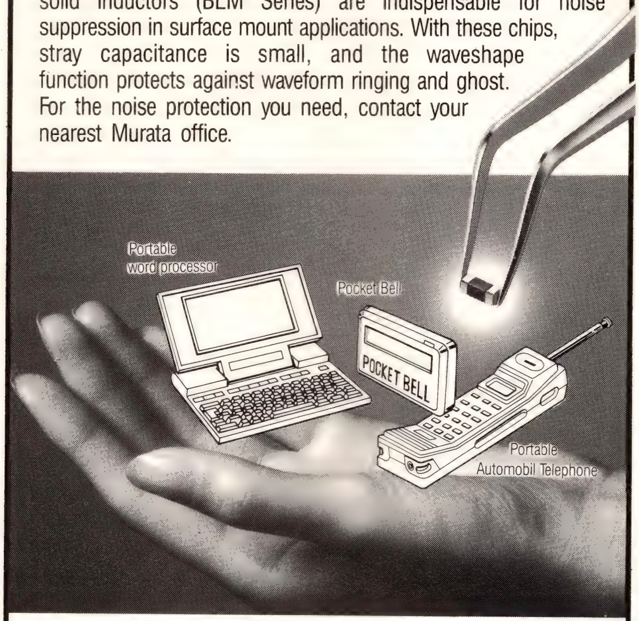

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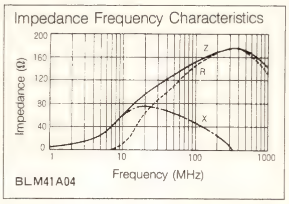

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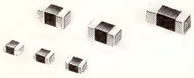

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Circle 164

MORE ARBITRATION SEEN AFTER IBM DECISION

The settlement of the software dispute between IBM and Fujitsu could lead to increased use of arbitration rather than lawsuits by electronics companies in disputes over product rights. Arbitration not only saves management time but "assures that decisions will be made by knowledgeable experts rather than judges and juries who cannot understand complex technology suits," says Peter Marx, a veteran computer-industry lawyer and counsel to the Information Industry Association. In the decision, IBM Corp. gets $833.2 million (including $600 million already paid); Fujitsu Ltd. gains limited access to IBM software.

PRIME NIXES MAI, GETS AN OFFER

Although Prime Computer Inc. has rejected as inadequate a hostile tender offer from MAI Basic Four Inc., the action may not be over. The rejection didn't close the door on a sweetened offer from MAI, and there may be another potential buyer in the wings. But, says Prime, it is not now involved in substantive discussions that could lead to a merger or leveraged buyout.

AT&T CAMP IS NOW 'UNIX INTERNATIONAL'

The industry association formed to support and promote AT&T's Unix System V, known informally as the Archer Group, is now officially Unix International. The association currently boasts 29 members that represent a stellar roster of computer-industry companies in Europe, the U. S., and Japan. Donald J. Herman, retired senior executive of NCR Corp. and founding chairman of the Corporation for Open Systems, has been named organizing chairman.

UNISYS SHUFFLES MANAGERS AND UNITS

Unisys Corp., the $10 billion information-systems manufacturer in Blue Bell, Pa., has decentralized its management and its organization. Paul C. Ely Jr., chairman of newly acquired Convergent Inc., will be president of a new network-computing group, and James A. Unruh, a Unisys executive vice president, will take over all commercial marketing. Also, separate product-marketing and development groups have been set up.

PEOPLE TO WATCH

A HARDWARE MAN SHIFTS GEARS AS FRANKEL TAKES OVER AT RETIX

He's discovering that in fast-growing OSI world, 'software will set the rules'

SANTA MONICA, CALIF.

Sometimes Stephen W. Frankel still can't figure out how a hardware man like him wound up as president of a software-oriented company like Retix. At those moments, he asks himself, "What am I doing in this far-off land?"

Retix supplies standard products for communications networking, mainly in the Open Systems Interconnect market. As it turns out, the answer holds considerable interest for those seeking to understand the business, which is growing at a 100% annual clip. Simply put, for technology based on OSI standards, you need software to implement the OSI protocols before anything can happen. This is a switch from the usual course of events in networking products, where new hardware nearly always comes first and the software is written afterward, sometimes years later.

"It is so crystal clear—software will drive [the protocols] and set the rules for 10 years. And the hardware guys have to accommodate themselves to the software," says Frankel.

Actually, Frankel had the chance to zero in on the OSI marketplace for several months last spring, because for the first time in 22 years he was out of a job. A restructuring at Emulex Corp., the Costa Mesa, Calif., manufacturer of communications and data-storage systems, ended his stint as president. He used the unaccustomed leisure to identify the business that offered the best opportunity for a launch. At that point, working for someone else again was the last thing on his mind, and he turned down a number of offers.

The conclusion Frankel drew from his study is no surprise to anyone familiar with OSI growth rates: it offers the best of all opportunities, particularly the X400 electronic-mail segment. So there was Frankel, with his idea for a new OSI company, and Retix, with its need for an executive who could speak the language of chip and computer firms. Their help is required to spur growth.

Frankel came to call during the summer, bent on exploring how his prospective company might be able to work with Retix. Instead, as discussions lengthened, it became apparent that if he took the president's post, it could fill the bill for both parties. "It was a long courtship, at least 10 meetings. Usually, I only need one to decide something," observes Frankel.

Besides a sharp understanding of Retix's OSI role, Frankel offers some other management tools that fit the firm's present needs, says Thomas Brett, board member and general partner at Menlo Ventures in Menlo Park, Calif. "He has dealt with complex issues before, and 1989 is the year when Retix has to focus on specific opportunities. I've known Steve for nearly five years and he has the skills and energy to get this job done." Retix now has sales of about $25 million annually, including the December acquisition of TSL Communications, an English manufacturer of local-area-network bridges and related products. It projects doubling this revenue in 1989.

Frankel wasted no time in using his connections to get hardware manufacturers interested in Retix. "I'm fielding calls every day from them now," he says, and many are paying off. At this point, the gap between his understanding of how to manage hardware and software is narrowing. "In fact, [the difference] shouldn't matter, if you keep in mind what the customer wants and the market needs," he notes.

One remaining difference is in actually putting the software to work. "The implementation phase of software today is vastly more complex than that of hardware," says Frankel, a point that managers must increasingly take into account. As would be expected, dealing with it gets high priority at Retix.

The geographical transition for Frankel, 42, has been painless: he continues to live in the posh Palos Verdes section of Los Angeles, which is equidistant from his previous job in Orange County and his present post at Retix. "That was nice advance planning, wasn't it?" he says with a smile.

–Larry Waller

Stephen W. Frankel, who until recently was exclusively a hardware executive, walked into Retix to talk about his proposed new company and wound up occupying the president's chair.

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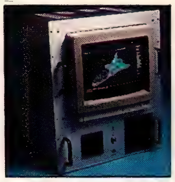

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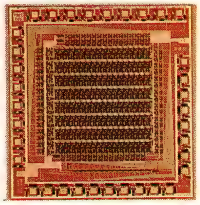

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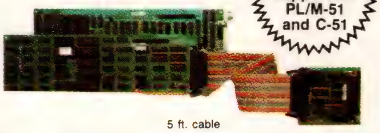

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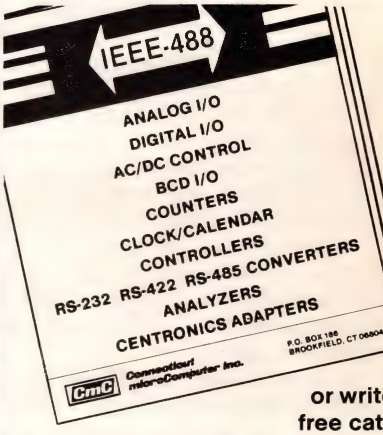

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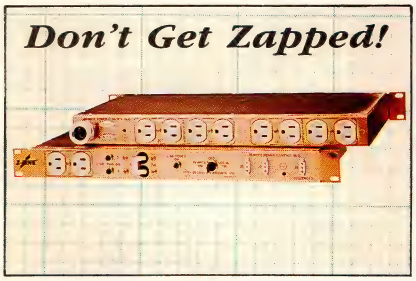

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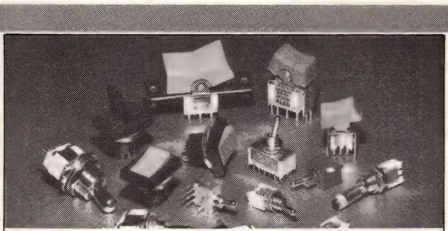

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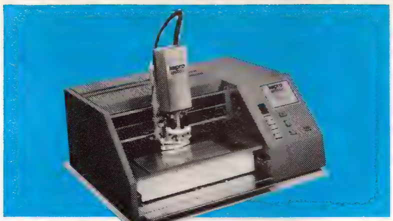

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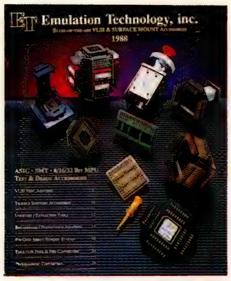

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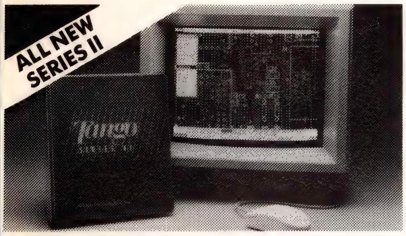

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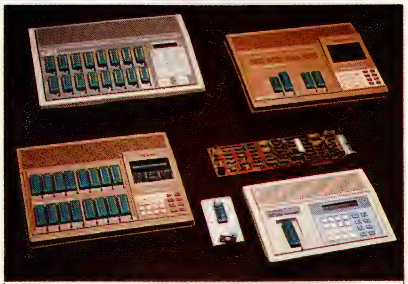

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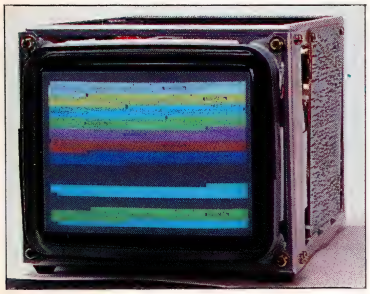

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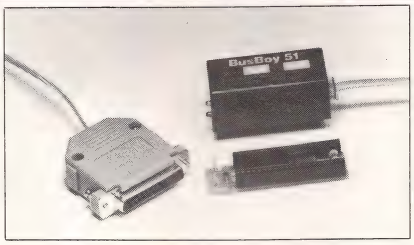

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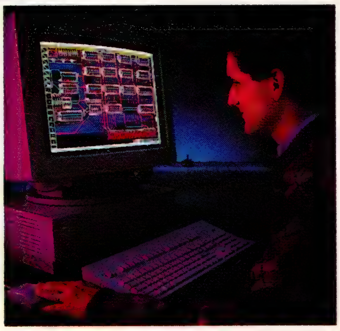

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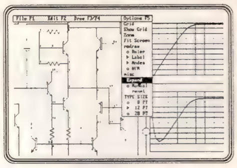

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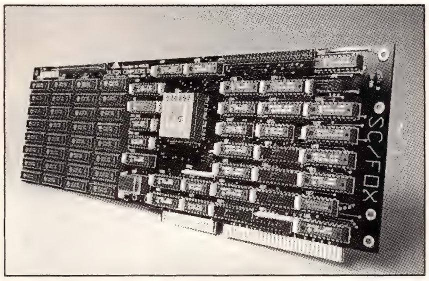

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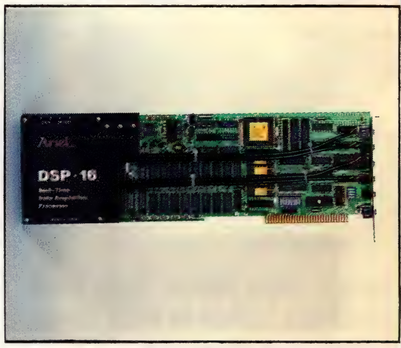

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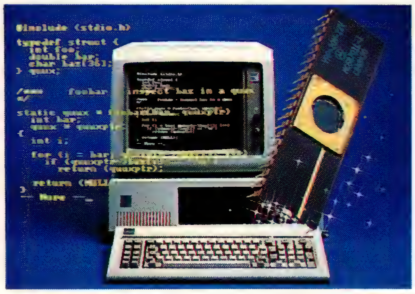

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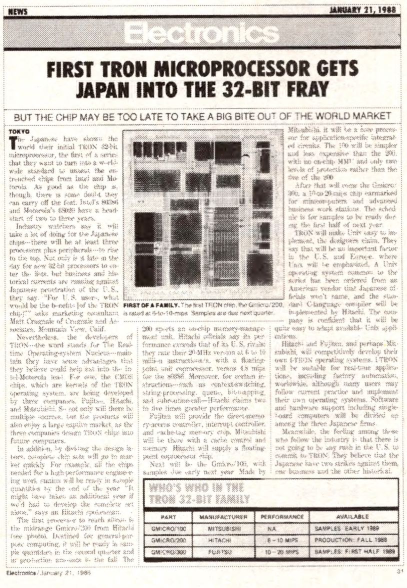
UPDATE: TRON MOVES IN—TO REAL-TIME CONTROL

The electronics world is paying close attention these days as the Japanese develop 32-bit microprocessors for the TRON operating system, an operating system that has been developed in Japan in hopes of setting major new software standards. In the excitement, very few have noticed that a powerful thrust is well under way in a less glamorous market segment: TRON-compatible microcontroller chips.

These chips, which are being brought to market by Fujitsu, Hitachi, and Mitsubishi, fulfill one of TRON's original missions. After all, TRON, which stands for The Real-time Operating-system Nucleus, is a series of general specifications for developing a group of interlocking operating systems that process data fast enough to respond to events in the real world. The new chips provide systems houses with a range of choices for implementing real-time control systems.

Because the chips are compatible with a subset of the industrial version of TRON—ITRON—customers can write their software in the high-level C language, with the capability of compiling that code for use with any of the microcontroller chips from different vendors. This is a significant development in the world of real-time control, because until now, programs were almost exclusively written in the assembly language of the target microcontroller or microprocessor, and thus were not portable from processor to processor. With TRON, code for these applications becomes portable—within the TRON world, at least—allowing systems houses to reuse their software resources.



NEWS JANUARY 21, 1988

Electronics

FIRST TRON MICROPROCESSOR GETS JAPAN INTO THE 32-BIT FRAY

BUT THE CHIP MAY BE TOO LATE TO TAKE A BIG BITE OUT OF THE WORLD MARKET

TOKYO

The Japanese have shown the world their initial TRON 32-bit microprocessor, the first of a series that they want to turn into a worldwide standard to unseat the entrenched chips from Intel and Motorola. As good as the chip is, though, there is some doubt they can carry off the feat. Intel's 80386 and Motorola's 68020 have a head-start of two to three years.

Industry watchers say it will take a lot of doing for the Japanese chips—there will be at least three processors plus peripherals—to rise to the top. Not only is it late in the day for new 32-bit processors to enter the lists, but business and historical currents are running against Japanese penetration of the U.S., they say. "For U.S. users, what would be the benefits [of the TRON chip]?" asks marketing consultant Matt Crugnale of Crugnale and Associates, Mountain View, Calif.

Nevertheless, the developers of TRON—the word stands for The Real-time Operating-system Nucleus—maintain they have some advantages that they believe could help eat into the Intel-Motorola lead. For one, the CMOS chips, which are kernels of the TRON operating system, are being developed by three companies, Fujitsu, Hitachi, and Mitsubishi. So not only will there be multiple sources, but the products will also enjoy a large captive market, as the three companies design TRON chips into future computers.

In addition, by dividing the design labors, complete chip sets will go to market quickly. For example, all the chips needed for a high-performance engineering work station will be ready in sample quantities by the end of the year. "It might have taken an additional year if we'd had to develop the complete set alone," says an Hitachi spokesman.

The first processor to reach silicon is the midrange Gmicro/200 from Hitachi (see photo). Destined for general-purpose computing, it will be ready in sample quantities in the second quarter and in production amounts in the fall. The 200 sports an on-chip memory-management unit. Hitachi officials say its performance exceeds that of its U.S. rivals: they rate their 20-MHz version at 6 to 10 million instructions/s, with a floating-point unit coprocessor, versus 4.8 mips for the 80386. Moreover, for certain instructions—such as context-switching, string-processing, queue, bit-mapping, and subroutine-call—Hitachi claims two to five times greater performance.

Fujitsu will provide the direct-memory-access controller, interrupt controller, and cache-tag memory chip. Mitsubishi will be there with a cache control and memory. Hitachi will supply a floating-point coprocessor chip.

Next will be the Gmicro/100, with samples due early next year. Made by Mitsubishi, it will be a core processor for application-specific integrated circuits. The 100 will be simpler and less expensive than the 200, with no on-chip MMU and only two levels of protection rather than the five of the 200.

After that will come the Gmicro/300, a 10-to-20-mips chip earmarked for minicomputers and advanced business work stations. The schedule is for samples to be ready during the first half of next year.

TRON will make Unix easy to implement, the designers claim. They say that will be an important factor in the U.S. and Europe, where Unix will be emphasized. A Unix operating system common to the series has been ordered from an American vendor that Japanese officials won't name, and the standard C-language compiler will be implemented by Hitachi. The company is confident that it will be quite easy to adapt available Unix applications.

Hitachi and Fujitsu, and perhaps Mitsubishi, will competitively develop their own I-TRON operating systems. I-TRON will be suitable for real-time applications, including factory automation, worldwide, although many users may follow current practice and implement their own operating systems. Software and hardware support including single-board computers will be divided up among the three Japanese firms.

Meanwhile, the feeling among those who follow the industry is that there is not going to be any rush in the U.S. to commit to TRON. They believe that the Japanese have two strikes against them, one business and the other historical.

FIRST OF A FAMILY. The first TRON chip, the Gmicro/200, is rated at 6-to-10-mips. Samples are due next quarter.

WHO'S WHO IN THE TRON 32-BIT FAMILY

PART	MANUFACTURER	PERFORMANCE	AVAILABLE
GMICRO/100	MITSUBISHI	NA	SAMPLES: EARLY 1989
GMICRO/200	HITACHI	6 – 10 MIPS	PRODUCTION: FALL 1988
GMICRO/300	FUJITSU	10 – 20 MIPS	SAMPLES: FIRST HALF 1989

Electronics/January 21, 1988 31

At the same time, products using 32-bit TRON processors are arriving

That TRON world will soon encompass three microcontroller products, and a fourth is on the way. These new 8- and 16-bit designs, compatible with the μITRON subset of ITRON, are bringing code portability to this market. The μITRON subset provides a common programming environment by standardizing system calls.

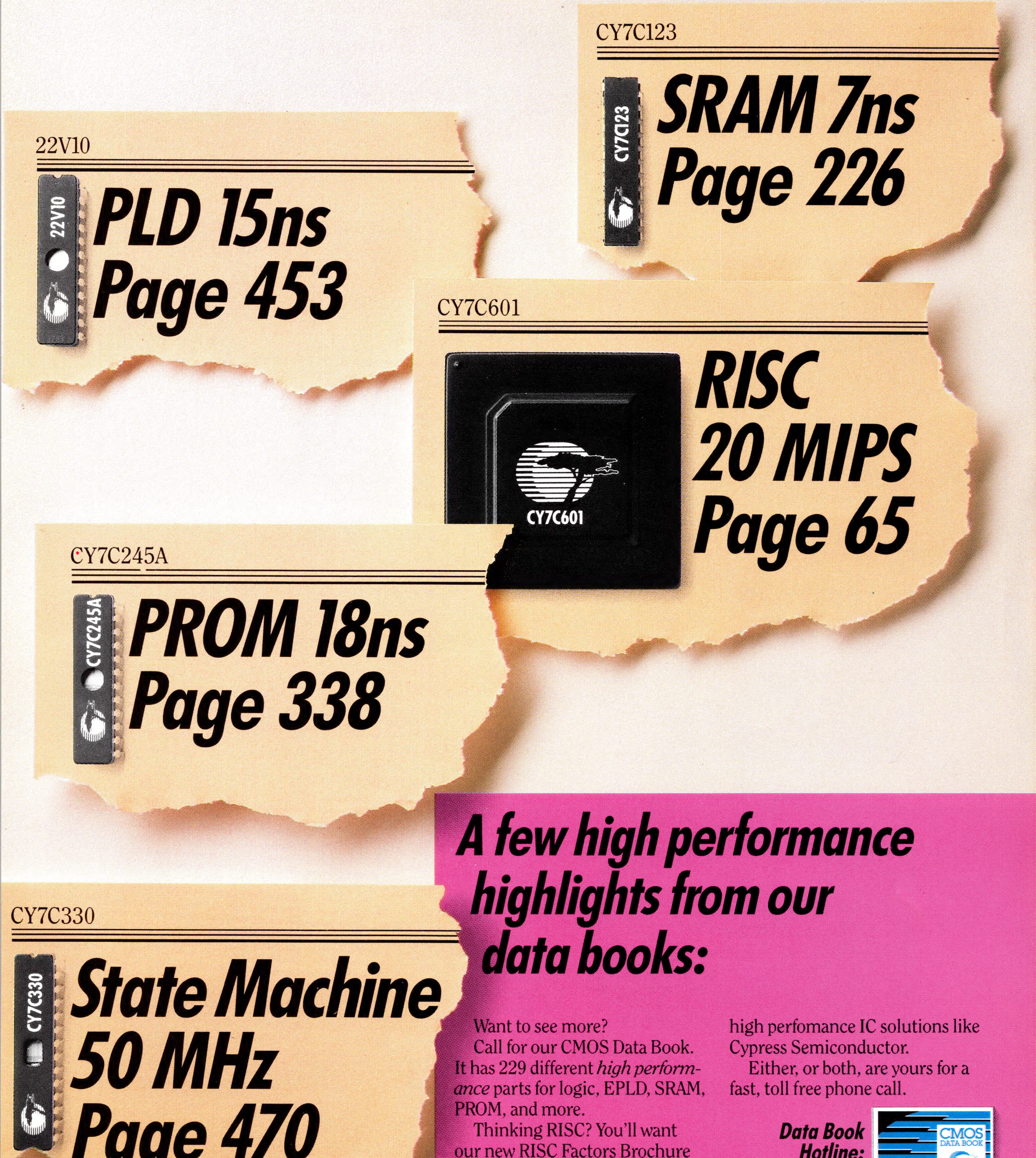
In December, Hitachi Ltd. of Tokyo started sales of its H8/500 series 16-bit microcomputers (with an 8-bit external bus) and its HI8 real-time operating system. Mass production will start in the second quarter of 1989. Mitsubishi Electric Corp. of Tokyo is about to chime in with its MELPS 7700 series 16-bit microcomputers and its MR7700 operating system. Although the operating systems conform to μITRON specifications, they are specific to a single-chip architecture. Moreover, the chips for a particular application have individual system and application read-only-memory code.

Two other companies hope to close in on the leaders. Fujitsu Ltd. of Tokyo says that its MB89700 series 8-bit microcomputers—which it also calls the F^2MC series, for Fujitsu flexible microcontroller—and the REALOS/97 operating system will be available this spring. Matsushita Electronics Corp. of Tokyo has also announced that it is developing a chip and an operating system.

Next to this nearly unnoticed development, the rest of the TRON news pales in significance. All eyes have been drawn by the fact that a so-called TRON architecture was adopted in an attempt to come from behind in the 32-bit-microprocessor business [*Electronics*, Jan. 21, 1988, p. 31]. But in the market for 32-bit general-purpose microsystems, TRON is unlikely to become an important factor. Two of the three 32-bit chips being developed in Japan are intended not just to run under TRON, but to run under Unix and other operating systems as well; their manufacturers realize that in this market segment, Unix is far more widely used than TRON is likely to be. Conversely, other 16- and 32-bit microprocessors already out from Intel, Motorola, National, and NEC run very nicely under TRON. Despite the fact that TRON is unlikely to have major impact in 32-bit general-purpose computing, the effort has drawn lots of attention. Products called "Business TRON personal computers"—which may be used in education—have also been making news.

On the 32-bit front, three Japanese makers—Hitachi, Mitsubishi, and Fujitsu—last year agreed to make slight modifications in the TRON chips that they had independently started developing so they could share peripherals and cooperate in marketing. They also agreed to sell each other's TRON chips and peripherals. Toshiba Corp. of Tokyo neither joined the group nor made its chip hardware-compatible. Since then, Oki Electric Industry Co. of Tokyo and Matsushita have said they also are working on 32-bit chips. Neither has said whether its offering will be compatible with other processors.

At the time Hitachi, Mitsubishi, and Fujitsu agreed to cooperate, the schedule called for the first processor, from Hitachi, intended for general-purpose computing, to be ready in production quantities last fall. The second, Mitsubishi's core processor for application-specific ICs, was to appear this quarter. Third was to be Fujitsu's chip, intended for minicomputers and advanced business work stations. The Hitachi and Mitsubishi TRON processors were to be introduced by now, but Hitachi's chip is barely in the sampling stage, and samples of the Mitsubishi chip now are scheduled for sometime this spring. Fujitsu's chip isn't due until late 1989, so it still could appear on schedule. *–Charles L. Cohen*



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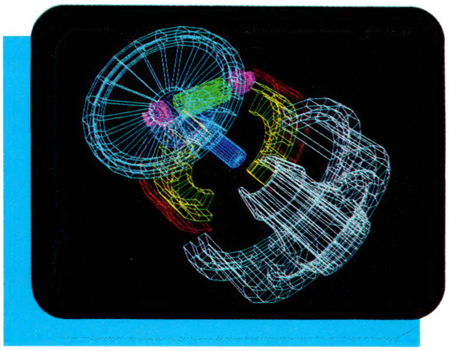

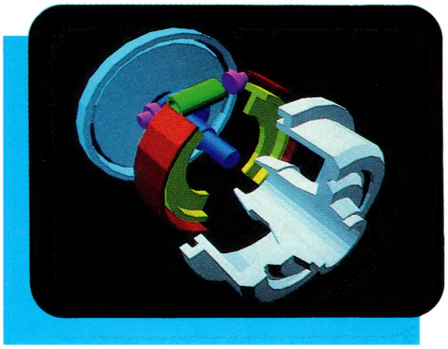

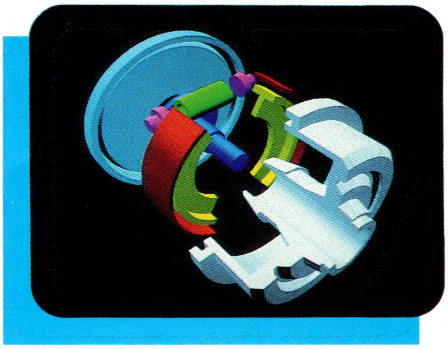

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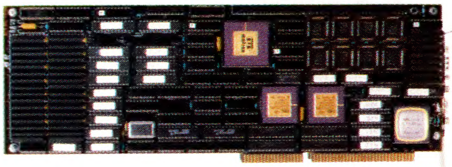

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